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SCHOOL SCIENCE AND MATHEMATICS

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THE COLLEGE STUDENT'S KNOWLEDGE OF HIGH SCHOOL PHYSICS

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On the question of the value of high school work in physics to the student entering a college class in the subject, there is no unanimity of opinion amongst college physics teachers. There are a few who think that the college should offer two courses—one for those students who have had a year of physics in the high school, and another and more elementary course for those who have not studied the subject. At the other extreme are those teachers who maintain that they prefer students who have not had any physics work in the high school and who, therefore, have "nothing to unlearn." Between these extremes are those teachers who say that they do not care whether or not their students have had high school physics, that they place those who have had and those who have not had the work in the same class and that the two groups make practically the same grades in their college work.

Believing that opinions should be founded on facts rather than on impressions, the writer concluded to give his beginning students an examination to discover how much of their high school physics had been carried over into the University.

It was carefully explained to the class that the examination was a pedagogical study and that the grade made by a student would not be considered in determining the grade on his term of college work. The students were urged to co-operate with the teacher by trying to answer every question, whether certain or doubtful as to the answer, and whether they had taken or had not taken physics in their high school course. I am sure that there were very few cases in which the student did not do his best.

At the first session of the class, the fall term of 1916, each

student was handed a three page list of questions. The first page was as follows:

TABLE I.

Date

College
Name
From what high school did you graduate?
Date?
Did you study physics in the high school?
How long?
Have you studied physics in any college or normal?
Where? How long?
What subjects?
Of what college class are you now a member?
What is your major study?
Have you ever taught physics? How long?
Where?

Please answer quickly and briefly the ten questions on the accompanying lists. If you are not sure of the correctness of your answers, give them anyway.

On the second and third pages was a list of ten physics questions with sufficient space after each question for the student to write his answer. The questions were as follows:

TABLE II.

1. What is the resulting volume if 1,000 cubic cm. of gas at a barometric pressure of 1 atmosphere (76 cm. of mercury) be subjected to an additional pressure of 4 cm. of mercury?
2. Taking the coefficient of expansion of steel at .000011, find the total length of an iron bridge at 20° C. if its length at 0° C. is 100 feet.
3. What is meant by the statement that the specific heat of iron is 0.113?
4. A 2 candle power lamp is placed 1.5 meters from a screen. Where must an 8 candle power lamp be placed to produce the same illumination on the screen?
5. What is the apparent color of a pure red (monochromatic) object when viewed in pure (monochromatic) blue light?
6. What is meant by the statement that a lens has a focal length of eight inches?
7. What causes the refraction of a beam of light when it passes from one medium into another?
8. What current will flow when the terminals of a 1 volt cell having an internal resistance of 2 ohms are connected through a resistance of 5 ohms?
9. What current is required to operate a 40 watt 110 volt incandescent lamp?
10. What principle is illustrated when a dynamo is generating a current? In other words, how does the dynamo generate an electromotive-force?

In preparing the above questions, an effort was made to make the list equally fair to physics teachers using widely different methods. Some high schools have practically no equipment or an equipment that is useless because of unintelligent selection. The teacher in such a school is likely to be burdened with classes in several subjects and thus be forced to make his physics work wholly text book work. He may stress theory, or definitions, or problems.

Another teacher who has more time and more equipment emphasizes laboratory practice. Still another believes that physics must be practical and that nothing is practical that does not have to do with watts, or horsepower, or some other term used in commerce or industry.

The writer graded the 110 papers returned on this examination, made a detailed study of the results, and presented the data and conclusions to the college physics teachers of Indiana at the annual meeting of the club, May, 1917. The club voted that the writer extend the study to include the beginning physics classes of the several Indiana Colleges represented at the meeting. The writer expected to make the study the following fall, but owing to war excitement and to the disturbed school conditions immediately following the war, the study was postponed till the fall of 1920 when the examination was given in seven Indiana colleges besides Indiana University. The fall of 1921 the examination was repeated in Indiana University and in two colleges not on the 1920 list. The writer in every case sent to the college giving the examination a supply of question sheets identical with those used in the 1916 examination. The examination was given at the opening of the fall term and the papers were returned to the writer for grading. Thus all the students taking the examination, 1,058 in number, wrote on the same questions and all the papers were graded by the same person.

The teachers and institutions co-operating with the writer and Indiana University in this study were: Professor Ryland Ratliff of the Central Normal College (C. N. C.), Professor J. P. Naylor of DePauw University (D. P.), Professor L. E. McCarty of Earlham College (Earl.), Professor J. E. Smith of Franklin College (Frank.), Professor E. S. Ferry of Purdue University (Pur.), Professor E. S. Johonnott of Rose Polytechnic Institute (Rose), Professor Robert G. Gillum of the Indiana State Normal School (St. N.), Professor B. A. Howlett of Valparaiso University (Val.) and Professor E. K. Chapman of Wabash College (Wab.).

Table III summarizes the results of the several examinations. Column 1 suggests the nature of the questions, columns 2 to 11, inclusive, give for each question the average grades (on the basis of 10 per cent per question for the ten questions) of all the students of the ten colleges participating in the study. Column 12 gives the weighted average of all these grades—each institution grade being weighted in proportion to the number of students making that grade.

TABLE III.
AVERAGE GRADES (%) OF ALL WHO HAD STUDIED HIGH SCHOOL PHYSICS.

	1 Question	2 C.N.C.	3 De. P.	4 Earl.	5 Frank.	6 Ind.	7 Pur.	8 Rose	9 St. N.	10 Val.	11 Wab.	12 W. Av.
1	100 c. c. gas at 76 Vol. at 80?	2.5	1.7	3.1	3.3	3.3	2.5	3.4	2.2	3.0	4.0	2.7
2	Length 100 ft. bridge when t. rises 20°?	2.5	4.3	2.1	3.2	3.6	3.1	5.2	7.2	5.0	3.7	3.5
3	Specific heat?	0.0	1.5	1.5	1.5	1.7	1.0	2.8	4.6	3.2	1.9	1.4
4	2 c. p. lamp at 1.5 m. Where 8 c. p.?	0.0	0.5	0.5	0.3	0.7	1.1	0.2	2.1	4.0	1.1	1.0
5	Color of red object in blue light?	2.5	0.5	0.5	0.9	1.9	0.8	1.6	2.2	2.0	0.0	1.5
6	Focal length of lens?	0.0	0.5	0.4	0.3	1.3	0.5	1.6	0.0	1.0	0.6	0.9
7	Cause of refraction?	1.2	2.4	2.1	1.6	2.2	2.2	1.3	3.4	1.9	2.2	2.7
8	1 volt thru 5 ohms. What the current?	0.0	0.5	2.1	1.5	1.5	1.2	2.7	0.1	2.0	0.5	2.5
9	40 watt 110 v. lamp. What the current?	0.0	0.5	0.5	1.1	1.4	1.2	2.0	0.0	1.0	0.4	1.2
10	Dynamo principle?	0.0	1.7	2.5	5.0	2.2	3.0	2.4	0.1	1.8	4.0	2.3
	Total Grade	8.7	14.1	15.3	18.7	19.8	16.6	23.2	21.9	24.9	18.4	19.7

The last line of Table III gives the total grade on all ten questions, *19.7% being the weighted average of the grades made by 851 students who had studied physics one year in the high school.*

The limits of this paper preclude a detailed discussion of all the points suggested by a study of Table III, and of the other tables in which the grades have been analyzed from other view-points. The reader must do most of the theorizing. The writer will confine himself to a few points.

The differences shown between the grades of the students of the several colleges are easily explained. The relatively high or relatively low average of some of the schools having small classes is accidental, a particularly good or a particularly poor paper changing the average grade by several points. The Purdue average was brought down several points by fifty agricultural students whose average grade was about half of that made by students in other fields.

The claim that physics can be "put across" by dealing with "practical" things is not substantiated by this study. The majority of teachers certainly agree that question nine is a practical question, and that question seven is more theoretical. Yet one student of every four answered seven correctly, and but one of every eight could answer the ninth. And what is even more to the point, the students who were from high schools in which the teachers claimed to emphasize practical physics did not average better grades on this question than were made by students of other schools.

Poor grades can not be attributed to lack of laboratory equipment. Take, for instance, question six. The point can be experimentally demonstrated with a spectacle lens. Yet the grade made on this question was the lowest of all, only one student in eleven answering the question correctly. Questions four and five can be experimentally answered with very little equipment, while one, two and ten require considerable equipment. Yet the average grades on the latter questions were the higher, even in the case of those schools known to have little or no apparatus.

Whatever else we may see in Table III, the one outstanding fact is that the pick of high school physics classes (as those students who go to college are supposed to be) can answer only one question in five on such a list of physics questions as was

used in this examination.* I shall discuss this point later. Just now I wish to answer some of the points raised by a group of high school teachers to whom I showed the data given in Table III, and who were very much surprised at the poor showing made by their students. In explanation some thought that the students had simply forgotten their high school physics in the interval between the completion of their high school course and the examination. Others held that the low average grade was due to the very inferior work done in a few high schools, chiefly "small high schools with few teachers and limited equipment."

TABLE IV.

Time between high school graduation and this examination	Number Examined	Average Grade
Less than one year	67	20.1%
More than one and less than two years	330	15.8%
More than two years	334	14.7%

Table IV shows that the actual amount of physics forgotten by the students could not have been very great. From 20.1% to 14.7% in two years and more is a large relative but a very small actual loss.

TABLE V.

Where Physics work was done	Number	Grade
One year in large high school	304	21.0%
One year in small high school	547	17.1%
High School Graduates, no physics	120	5.7%

Table V shows that the small high school is not responsible for the low average grade made on this examination. In the table the writer has included under the heading "large high schools" all high schools in cities having a population of fifteen thousand or more. The "small high schools" include all others—both commissioned and non-commissioned. The table shows a difference of less than 4% in favor of the large high school. The grades made by those coming from most of the small high schools were fully as good as were made by students from the large high schools. The facts are that the knowledge of physics acquired in a high school class can not be gauged by the size of the school or the excellence of its material equipment. A striking proof of this assertion is the fact that in a certain large city having two high schools with practically equal enrollments and having supposedly equal facilities, the average grade of the students from one of the schools was 34.5%, from the other school 13.3%. Of the 851 high school graduates who had had a year of high school physics, there was but one student who made 100% on the examination, and he was from one of the smallest high schools in the state.

People in Indiana have learned that because a basket ball team hails from some unheard of school—a school so small that every male student must play in order to secure a team of five, is no reason to suppose it can not or will not win over teams carefully groomed by high salaried coaches and chosen from hundreds or even thousands of aspiring players. The team from the cross road school house may "put it on the map." If losing teams could take their cities off the map, the names of a number of Indiana cities would not appear. If a map were made on which the size of the type used in printing the name of a town was determined by the quality of the physics work done in its high school and not by its population, people would have trouble in recognizing their state. A number of towns, some with popular and supposedly efficient physics teachers, would not be on the map at all. Of sixty-five students coming into the writer's class from a certain high school in Indiana, more than eighty per cent failed to pass their first term's work. Of eighty students entering from another school, eighty-five per cent passed. Neither school appeared to have the advantage of the other in material equipment. The difference was in the teacher and in the spirit of the school in which he worked.

TABLE VI.

Preparation in Physics	Number	Av. Grd.
One year of high school physics	851	19.7%
One term or more, normal school physics	40	23.9%
One term or more, college physics	27	29.8%
No previous work in physics	140	4.6%
Men	978	19.7%
Women	80	11.0%
Men and Women	1058	18.1%

Table VI needs little comment. There was but a small difference between the grades of the students who had had a year of physics in the high school and those who had taken a term or more in a normal school or college. This is partly due to the fact that about half the latter had taken but one term in a normal school or college, and to the fact that those who had taken a year's work were inferior students or they would not have been taking beginning college physics a second time. However, the student may not have had any *real* college physics. ***A course based on a text book of high school grade is not college physics, even though the work be done within college walls.***

Table VI shows that as a class high school boys are probably more interested in physics than are the girls. However, the

difference is not as great as the table indicates, for the per cent of girls who had not studied physics in the high school was greater than in the case of the boys. Eliminating from each group those who had not taken high school physics, the difference in the grades was small.

TABLE VII.

Major Study in College	Number	Grade
Engineering	262	15.8%
Mathematics	86	16.0%
Physics and Chemistry	96	24.6%
Agriculture	50	9.3%
All others	387	12.0%

Table VII shows that the "major" study of the college student is reflected in the grades made on his physics work in the high school. It is doubtless a question of where the student's interest lies, and not as to his ability. The low grade of the students of agriculture does not mean a low average of intelligence. It is due in large measure to the regrettable fact that students of agriculture, as a group, do not see where physics is practical for them.

Another point that was raised by the high school teachers commenting on the results of the examination, a point which should be taken into consideration by the reader, had to do with the rigidity of the grading. A very rigid grading would have reduced the average grade of the class to less than 10%, a very loose grading might have raised it to 30%.

The writer was not at all exacting in his grading on these examinations. He gave the student a zero grade when he said that the focal length of a lens is the distance from the lens to the focus. But he gave a full grade when he said it was the distance from the lens to the principal focus even though he did not define principal focus and might not have known what the term means. He gave a full grade when the student evidenced in any way that he had parallel rays in mind, whether he said that the rays must be parallel, or that the object must be far away, or simply drew a figure showing parallel rays and locating the focus. The student was not required to say anything about the optical center of a lens.

The student was given a grade of five on the third question when he said that "the specific heat of a substance is .113 when that amount of heat is required to heat it one degree." A strict grader would give zero on such a definition.

It is true, of course, that the majority of the students on these

examinations were from Indiana high schools, and that the results apply particularly to the State of Indiana. There is no occasion, however, for some of her sister states swelling with pride over the record made by their students. The number of high school graduates from some other states who took the examination was sufficiently large to warrant the statement that their grades averaged about the same as those made by graduates of Indiana high schools.

Let me say, further, that there is no occasion for teachers of other subjects to disparage the work of their colleagues in physics. The high school student gives far more time to English and mathematics than to physics. The papers returned on these examinations show that a considerable per cent of our high school graduates can not write intelligible English, that they do not reason, and that they can not apply the simplest mathematics to the solution of a physics problem of the simplest kind. These are strong statements and ones that the writer dislikes to make. He would not make them had not their truth been forced on him by the results of this examination. The writer will give to substantiate them but a few of hundreds of illustrations that might be given.

What does one think of the reasoning ability of 115 students who found the length of a 100 foot iron bridge to be more than 2,000 feet when the temperature rises 20 degrees; of the 7 students who found the bridge to be over 200,000 feet long at 20°; of the mathematics of 80 students who could not place the point when multiplying by the decimal in question 2 ?

What should one think of the reasoning ability and the practical knowledge of the 147 students who found that 4,400 amperes would be required to operate a 40 watt lamp; of the 43 who said it would require a current of 4,400 volts; of 200 others whose answers to this problem varied between 2 4-11 and (4400) 2^2 amperes *or volts*. One in seven expressed the current in volts, although the problem itself gives the voltage. Nineteen gave the current in ohms.

Take the answers to some of the questions as an illustration of unintelligible English:

Question 3.

"The heat at which it is most dense."

"It means that iron will expand at a certain temperature .113."

"The greatest heat without melting."

"It means that iron gives off a specific heat of .113 at normal temperature."

"It will take the same amount of heat acting on equal amounts of iron and water will heat the iron .113 calories more."

"Per cent of least retaining power."

"It is the heat where the molecules stop vibrating because they get so cold they don't move fast enough to keep moving very long time."

"The degree of temperature iron expels."

"Iron has that heat for chemical use."

"Amount of heat iron will stand before it will expand."

"The natural temperature of iron."

"The amount of heat in one square inch."

Question 5.

"Pail blue."

"The color would be a mixture of red and blue like a rainbough."

Question 6.

"It is 8 ins. to the first focus and every other one gains eight from the proceeding one."

"The lens will increase the distance of natural eyesight by 8 inches."

"Its exactness is for 8 inches is precise."

"Light looks same as normal 8 inches from lens."

"8 inches in width of light."

"Lens 8″ long."

"Four years is to long to remember these questions studied one simester."

Question 7.

"When the beam of light passes between two mediums the refraction is caused by the beam striking the horizontal side of the angle of refraction (or conversely) and being refracted off at rt. ∟-s at side it first strikes.'

"Particles of dust in the mediums."

"The reflaction is caused by strinking the rays of light to the surface of an object the smoother the surface the greater the reflaction."

Question 8.

"It is a positive current."

"Five ohms is the current."

"The current would not be any as all of the volt would be used up in the ohms."

Question 9.

"Alternating current" (40 students gave this answer).

"The current would half to be 40 wats to make the bulb look normal."

"The current would be only 40 watts for the rest of it more than 40 watts would be held in the storage battery."

Question 10.

"The dynamo takes up as much energy—friction as used in running the dynamo; which when connected to act on another object will give it that amount of force, cause it to move proportionally."

"The brushes meet with the contact points of the armiture which are magnitized and then the break comes."

"The friction of the brushes unites with the lines of force and attracts into the wires where the electricity leaves the magnits and runs into the cables connected to the transformers."

"I do not know anything pretending to this question."

"It is generated by two or more coils of wire have currents where one has more power to overcome the resistance of the other which by other appliances it produces a electrol motive force."

"By the friction of magnates.',

"Archimedes principal."

Table VIII brings us back to the question which occasioned this study—do college students who have had high school physics make better grades in their college physics class than are made by those who have had no previous work in the subject? The column "College grade" gives the average physics grade

made the first term or semester by the number of students noted in the column "Number," at the institution listed in the first column.

TABLE VIII.

EFFECT OF HIGH SCHOOL PHYSICS ON COLLEGE GRADES.

Institution	One year of high school physics: Number	One year of high school physics: College grade	No high school physics: Number	No high school physics: College grade
Central Normal College	4	87.0	7	85.1
De Pauw University	21	86.5	7	83.2
Earlham College	14	80.0	8	78.0
Indiana University	235	71.9	66	67.6
Rose Polytechnic Institute	65	80.1	21	76.3
Indiana State Normal	17	82.5	4	88.5
Valparaiso University	10	73.5	1	67.5
Wabash College	26	70.7	5	70.0
Weighted Average	392	77.7	119	72.6

The general agreement of the data shows that the results are not accidental. The reader will draw his own conclusions. The conclusions of the several college men co-operating in this study, to all of whom advance copies of this paper were sent, are expressed with more or less definiteness in the following comments, taken from letters to the writer in answer to a request for an opinion:

"Personally, I have not been able to see much difference in the grades of students who have had high physics and those who have not. In many instances the student who comes to the work without any previous study, works better than the others."

"The value of high school work in physics depends upon who teaches the subject and the spirit of the school. Sometimes the work is of great value, sometimes worse than useless. On the average, the showing is disappointing."

"For a long time I have been certain that our students bring no physics with them when they enter my classes. I am sometimes uncertain of the amount they take away. Of course, we do not conclude that the physics taken by the high school students was of no value, or that all of the teaching was bad. Students do not work hard enough nor in an efficient manner. Is not the fault largely due to the lack of seriousness on the part of students? Many are content so long as they 'get by'."

"In my opinion, the difference in the grades is a fair argument in favor of dropping the work in physics in the high schools. The difference does not warrant the extra time put in, and might be better spent in the study of elementary mathematics or some allied subject."

"So far as the knowledge of physics is concerned, my students who have had high school physics do no better work than those who have not had it. The personality and the training of the high school teachers are factors which largely determine the amount of knowledge that the student acquires."

"Do the students in our high schools learn anything except dancing and basket ball?"

"It is indeed disappointing that our present high school teaching of physics is shown to be such a complete failure. I should hate, however, to have the problem of high school physics solved by dropping the subject from the curriculum. It seems to me that a better solution would be to require a far higher grade of preparation for those who are allowed to teach the subject. It seems to be the weak teachers who are lowering the grade of the work done throughout the state."

"The study confirms my view that the benefit derived from high school physics is discouragingly small. However, I believe that the gratifying results obtained in some schools justify an effort to bring the weak schools up to this standard."

"Though I have never made a very accurate study of the matter, I have never been able to see that previous high school training has made much difference in the grades made by university students of the subject. I am not sure that the fault is with the teaching so much as with the attitude of pupils toward any sort of serious work in the schools at the present time. Other teachers are complaining about the character of the high school work as much as we physicists. All the teachers are not incapable, of course, so the trouble can not be laid entirely on the teachers. There is too much interest in everything but study—basket ball, society, dramatics, and everything but sincere work. And it is all made the first thing by the pupils and fostered and encouraged by the parents. I do not see what is to be the outcome of it as yet, but certainly it can not go on in this way and to the extremes that it has gone, if education is to mean anything in the future."

THE ROLE OF MEMORY IN ALGEBRA

By Charles H. Butler

The University of Chicago

Chapter II—A Study of the Memory Processes

Part I—The Fundamental Aspects of Memory

Introduction.

(*Continued from page 534, June, 1922.*)

Memory is distinctly a mental function. It is the reproduction of a former state of consciousness, with the realization of the existence, at some former time, of this state of consciousness, and since all consciousness is conditioned by the nervous system, we may say that memory, itself, is a *functional* state of mind resulting from certain conditions within the nervous system. What these conditions are, what causes them, under what circumstances they obtain, what their nature is, and other like questions come up for investigation, and form an integral part of a discussion of the psychology of memory. The recent psychologists have given us a great many important facts regarding the physiology of the mind, so that we may speak with some certainty on this aspect of memory.

The Physiology of Memory.[1]

The whole nervous system is made up of a multitude of individual nerve cells, or neuroues. These may be grouped into three classes: (a) the afferent neurones, or those which transmit impulses from the sense organs to the central nervous system, (b) the efferent neurones, which transmit impulses outward from the central system, and (c) the associating neurones, or "adjusters," which form the associations between the other types of neurones. In the cerebrum there are certain localized functional areas, and, in addition, large sections known as *associational areas.* These associational areas consist of an infinitely complex network of "adjuster" neurones, and it is in these areas that rational thought takes place.

To illustrate the general action of the nervous system, we may take the very simple case of response to a theoretically isolated sensation. A sensory (*afferent*) neurone is stimulated through its end organ. The impulse is transmitted toward the central system until it reaches the *end brushes* of the neurone. Here, however, it is transferred to an *associating* neurone,

[1]For a fuller discussion the reader is referred to any of the numerous modern texts on psychology.

which has some sort of connection, through its *dendrites*, with the end brushes of the afferent neurone. These connections are known as *synapses*. Their exact nature has never been discovered. After passing through the associating neurone the impulse is again transferred, this time to an *efferent* neurone. The transit to the end of this neurone completes the circuit of the impulse, and excites the response.

It will be apparent, when we consider that there are something like eleven billion neurones in the nervous system, and that each one has many possibilities of association, that so simple a case as we have described cannot actually take place. As a matter of fact, the very simple nervous reactions involve hundreds of neurones, and rational thought, which involves associations of ideas, each of which, in turn, involves a very complex association of neurones, doubtless entails an organization whose complexity is inconceivable to us.

We are now confronted with the questions as to how, out of such an infinite possibility of combinations, it is possible for a single definite idea to emerge. In the first place, there is an unaccountable preference of connections among neurones. Of all the possible connections which a nerve cell has, certain ones seem to offer less resistance to the impulse than others. Thus a faint preferred path of transit for the impulse is instituted by nature.

The next fact of importance is that every time a set of neurones transmits an impulse, an actual physiological modification takes place (probably in the synapses) and renders that particular association of neurones more permeable to an impulse of that particular character. Apparently the connections are strengthened in some way, and the resistance to the transferrence of the impulse correspondingly lessened. If, then, this association of neurones is the combination involved in a given reaction, then the association will be more easily formed and the reaction performed with less mental effort the second time. Again the passage of the impulse the second time only serves to fix more firmly the coördination established at first, and each succeeding employment of this neural group strengthens it more and more, until finally the association may become automatic, and the act be performed without mental effort.

Memory depends very directly upon this permanent establishment of paths of transmission for nervous impulses. Indeed this may be said to be the very basis of memory. Every state

of consciousness involves some particular coördination of neurones, and if memory is the reproduction of a former state of consciousness, it must necessarily involve the reproduction of the neural association accompanying that state. Now if this has been strongly and firmly established, it will offer less resistance to reconstruction than if it has been made only superficially.

The permanency or strength of the association does not depend entirely upon repetition. Other factors influence it in a very marked way, and the statements of laws of memory are simply recognition of the efficacy of these factors. Two of them are especially important: namely, (a) recency of the coördination, and (b) vividness of the experience. Following the suggestion implied above, we give three of the fundamental laws of memory: That will be best remembered which (a) has had most repetitions, (b) has occurred most recently, and (c) presented originally the most vivid or impressive stimulation.

Functional Aspect of Memory

We turn now from the physiological aspect of memory to get at its nature from another angle. We shall endeavor to point out some of its functional components, its relation to other conditions of the mind in action; the factors upon which it is dependent; and, finally, some of the possibilities and means of training the memory and of memorizing effectively. As corroborative evidence in support of the ideas that will be advanced, the reader is referred to the four works on pure and applied psychology that were canvassed in connection with this part of our discussion[2].

There is a very close correspondence between imagery, imagination, and recall or memory. Imagination is usually divided into three classes: reproductive, constructive, and creative. Reproductive imagination has implied in its very name one of the fundamental characteristics of memory: i. e. recall or reproduction of a former mutual state. Imagery, imagination and memory are alike in the possession of this common property: the image, or the idea. It does not follow, however, that they are identical, and upon examination, one difference appears. Although it is based upon a close distinction, it is regarded as fundamental and we must take cognizance of it. Angell[3] makes this difference clear:

[2]J. R. Angell, *Psychology*; W. James, *Principles of Psychology*; C. H. Judd, *Psychology*; F. N. Freeman, *How Children Learn*.
[3]Op. cit. p. 222.

"But there is one important difference between memory . . . and mere imagination. . . We might go on indefinitely having similar, or even identical, images pass through our minds, and, if we did not recognize them as having been previously portions of our experience, we should never in any strict sense be able to speak of having a memory process. In memory . . . we are aware of the ideas . . . as actually standing for items in our previous states of consciousness."

Thus, not all imagination is memory. An image or an idea may come into the mind, but unless it is accompanied by the consciousness that it has been in the mind at a former time, it will take on the character of a retention rather than of a real memory, and will thus lose its effectiveness as an instrument for the control or interpretation of present experiences. The recognition of the experience as not totally new implies the consciousness of its former existence. Thus even after it has habituated itself and requires no particular attention, it may still be regarded as a memory.

Memory Involves Several Factors.

There are several things that must be taken account of as requisite to a memory state. In the first place, there must have been an original experience or set of experiences to be remembered. There must have been an association of different elemental experiences with each other to make up a recognizable thought or concept. Even a percept involves the relating of different sensory impressions into a composite whole, to which a meaning can be given, and unless there is a meaning, the experience cannot take on the character of true memory. It is conceivable that it might be present in the mind at different times, but without interpretation it will remain simply a neural retention. Recall can come only in the case of experiences which have relations to other experiences, for it is through these relations that meaning is given. These relations are commonly expressed by the term "perception." Perception, then is one of the fundamental factors of all types of memory. It will be noted, however, that the application of this term is not limited to sensory perception, but may equally well include ideational forms of experience, and may include concepts as well as percepts.

In the second place, there is another type of relation which is nearly always involved. A percept or a concept is an isolated

sort of recognition, and while it is conceivable that such an experience might be present in the mind, even though unrelated to other percepts, it would be hard to find an instance where this is actually the case. An idea usually exists in relation to other ideas. It has a setting or background, for after all, there could be but a very superficial meaning attached to an utterly isolated idea. Moreover, all real thinking is the relational interpretation of ideas. When one recalls the appearance of a building, the image is not merely of the shape and color and apertures of the isolated structure, but there is also a feeling of its relation to the ground upon which it rests, of the span of sky visible above it, and probably of the relative position and appearance of the trees, shrubbery, walks, etc. A similarity between a perception and any of these familiar features of the setting may serve to start a train of ideas, and thus call to mind the image of the building itself. Thus recall depends very directly upon a more direct association of experiences than that involved in perception. It is an association of an idea itself, with different features that combine to give the idea a relativity, a setting, a background.

This relativity is characteristic of all thought. Any mental fact is acquired through its relation to previous experience. Nothing is entirely new, and strange. A particular *combination* of experiences may be unfamiliar, but its interpretation must eventually come in terms of the past and the familiar. This is the law of all learning. An unfamiliar coined word can be understood only by being explained or defined in words whose meaning is known. Thoughts may be regarded as the relation of more or less classified ideas; the more exact the classification, the more clear and definite will be the thought. And classification is nothing more nor less than an association or a relativity. This relativity is the fundamental means of recall. Just as proper indexing facilitates and expedites the location of a book in a great library, so the association and relation of ideas facilitate and expedite, and, indeed, make possible the recall of the appropriate one at any time.

The associations of experiences may be of different types. There may be a logical association or sequence, such as is found in the demonstration of a problem or in the brief for an argument. This type of association is of vital importance in all branches of mathematics and science. A second type is that resulting from the natural or accidental occurrence together of experiences,

Thus if one should chance to meet an old acquaintance in a foreign land, the associations of these two elements in the event will probably be a lasting one, because of the uniqueness or the unusualness of the occurrence. A third type of association may result from the voluntary relation of arbitrarily selected experiences which have no logical connection nor any other peculiar characteristics that would tend to make a natural association. This sort of association occurs in memorizing lists of nonsense syllables or multiplication tables. It is characteristic of rote, or mechanical, memory. It takes on a certain, though superficial, logical aspect, however, when mnemonic devices are employed to make the association stronger and more permanent.

The important thing to note is that association of which ever type it may be, is the fundamental means of recall, because all experiences are relative, are links in a chain or elements in a whole, and the grasp of one link or one element gives access to the whole, whereas there is no means of putting one's finger on a particular unit in a heterogeneous group of unrelated things. We shall have occasion to refer to the different types of association in our later discussion of different kinds of memory.

There is another factor involved in recall, however, and it must not be overlooked. This is *suggestion*. No matter how elaborate an association of experiences there may be, if there is nothing to "touch it off" it will not function, but will remain merely potential and dormant. As James puts it, there must be a psychological "cue" before there can be recall. There are psychologists who hold that every mental state and every act is consequent to some suggestion, whether the suggestion be consciously recognized or not. When we attempt an intro-retrospective analysis of the beginning of a number of experiences, we shall probably not be able, in every case, to verify this contention. It can be verified in a great many instances, however, and there is much evidence which tends to indicate that if it were possible to carry the introspection far enough, the theory would be found to hold in every case. Whether it is universally true or not, there can be no question as to the power of suggestion as a means for setting up particular trains of thought. Judd[4] points out that suggestion may result from contiguity or from similarity of experiences, and Freeman calls especial attention to its importance as a means of recall.

Factors in Strengthening Recall.

It is evident from a consideration of the foregoing discussion, that association of experiences is the basis, and association and suggestion the means, of recall or of memory (for since the term "recall" implies the fact that the experience is recognized as having been present in the mind at a previous time, it may be used synonymously with the term "memory"). The functional association corresponds to the physiological association of neurones, of which we have spoken in the first section of this chapter. It was then pointed out that the permeability and permanence of neural adjustments depends largely upon three factors: the vividness of stimulation, and the recency and the frequency of the passage of the impulse. Similarly, from a functional point of view, the facility and correctness of recall will correspond generally to the degree of vividness, recency and frequency of the association. These factors must be remembered in attempting to train the memory.

Training and Development of the Memory Processes.

Angell, in speaking of the training and development of the memory processes, confirms what has been said regarding the functional nature of memory and raises another consideration which is most germane to our discussion. We quote from his *Psychology*[6]:

> "A good memory, in the practical sense of the phrase, would seem to depend upon (1) ease and rapidity of acquirement, (2) permanency of retention, and (3) the ability to recall information promptly and actually, when wanted. These results clearly involve (a) *the original act of impression* (b) the process of *retention*, and (c) the *act* of *recollection*. The original impression and the act of recollection are under our immediate control."

The last sentence in this quotation suggests a question that requires further discussion: namely, *it is possible to train or to improve the memory to a higher degree of efficiency, and if it is, how can it best be done.*

The direct answer is found in a quotation from James' *Psychology*[7]:

> "All improvement of memory consists, then, in the improvement of one's *habitual methods of recording facts.* Methods

[4] *Psychology*, pp. 234-235.
[5] *How Children Learn*, p. 190.
[6] p. 237.
[7]—Briefer course. p. 298.

of recording have been divided into the mechanical, the ingenious, and the judicious. The *mechanical methods* consist in the intensification, prolongation and repetition of the impression to be remembered. The modern method of teaching children to read by blackboard work, in which every word is impressed by the fourfold channel of eye, ear, voice, and hand is an example of an improved mechanical method of memorizing.

"*Judicious methods* of remembering things are nothing but logical ways of conceiving them and working them into rational systems, classifying them, analyzing them into parts, etc., all the sciences are such methods. "Of *ingenious methods*, many have been invented under the name of technical memories. By means of these systems it is often possible to retain entirely disconnected facts, lists of names, numbers, and so forth, so multitudinous as to be entirely unrememberable in a natural way."

This quotation establishes the fact that only by improving any, or all, of the three general methods of memorizing, can the memory be made to function more effectively. We may well supplement the general methods given above by an enumeration of *rules for memorizing* given by Freeman[8]. They are as follows:

1. Get the meaning clearly in mind.
2. Make as many repetitions as are necessary to fix the arbitrary associations.
3. Continue the repetitions beyond the threshold of memory.
4. Distribute the repetitions.
5. Attempt to recall during learning.
6. Make the first perusal with especial care.
7. Avoid false associations.
8. Learn under some pressure.

There is no necessity for discussion of these rules. The aim of this division of our discussion has been simply to establish the fact, by reference to accepted authorities that memory can be improved, and to set forth the means whereby it can be made more efficient.

It is not to be assumed that all individuals possess equal powers of recall, not that it would be possible to develop these powers to the same degree in all individuals. On the contrary,

[8]See op. cit. pp. 193-204.

the widest differences are found in natural ability to memorize, and experiment has shown that differences equally as marked are found in capacity for development. Individuals differ in the characteristic ways in which they form associations, in the degree of retention, and in the facility with which they pick up and follow up "cues." The two extremes are found in idiots and prodigies. These individual differences, however, great as they are, do not affect the validity of the proposition that in general it is possible to bring about some improvement of the memory.

Part II—Types of Memory.

Two Kinds of Memory.

In surveying the pedagogical literature relating to the function of memory in school subjects, one is struck by the occurrence of two apparently widely divergent views. On the one hand, there are certain writers who hold that rationalized thinking should be the chief aim of education, and that memory has no place in rational thought processes. On the other hand, a second and larger group takes the opposite view, and maintains the extreme importance of memory as a factor in education. Among this second group are numbered many psychologists and educators of the first significance: such men as Angell, Thorndike, Judd, James and Freeman. When a number of such thinkers are in agreement upon a matter of educational significance, the opinion which they voice cannot but command the attention and respect of the profession. In a recent lecture, Dr. G. T. Buswell expressed his belief that in all branches of learning memory is a vital factor. Dr. C. H. Judd, in his *Psychology of High School Subjects*[9], makes very clear his conviction of its importance. Dr. F. N. Freeman shows his recognition its importance by devoting an entire chapter[10] to its consideration while Neumann has given us a whole volume on it[11]. These are merely instances which serve to make clear the fact that by many of the most eminent thinkers and writers, memory is reckoned among the vital constituents of the educative process. The prevalence of this attitude might be substantiated by many quotations, but in the interest of brevity we shall omit these.

As has been said, however, there is another point of view, of which Schultze's attitude is characteristic. In his *Teaching of Mathematics in Secondary Schools*, we find the epitome of this

[9] pp. 70-77.
[10] Op. cit., chapter X, pp. 185-211.
[11] *The Psychology of Learning.*

attitude[12]. It is here maintained that the function of the secondary school is not to train nor to utilize the memory, but to develop and prepare for efficient use the power of rational thinking. In one place the author says: "The principal value of mathematical studies arises from the fact that it exercises the *reasoning power more,* and claims *from the memory less* than any other secondary school subject." In another place[13] we find the following quotation:

"In the more advanced work, the very nature of the subjects makes mere memorizing ineffective . . The daily rations of mental food that the student has to swallow give him no choice; there is no time for thought, for meditation, for judicious study; he must memorize . . . It is knowledge, not power, that is emphasized in most of the studies, and even subjects which by their very nature should be mastered by thinking are often made informational. . . Can we wonder that under such conditions the student never breaks away from his mechanical way of studying that he acquired in the elementary school? And can we wonder, too, that the results of our teaching become inferior in the higher grades of the grammar school, and espcially so in the high school?"

To all appearances the two attitudes set forth are in direct antagonism, and in order to arrive at the truth of the matter, we shall have to subject both to close scrutiny. The key to the situation would seem to lie in the meaning which is to be attributed to the word "*memory.*" If it is taken to mean the ability merely to repeat, parrot-like, the facts included in the subject matter studied, then, indeed, Schultze's argument has a basis and validity worthy of great consideration. If, on the other hand, it may be interpreted as the recall of experiences in their proper application to appropriate situations, then it is evident that memory is not only *not opposed* to rational thought, but that without the aid of memory, rational thought is impossible. In the solution of a problem how often does the student find it necessary to make use of processes and facts learned previously? In the translation of a Latin passage, how can he manage without the aid of the rules of syntax and the vocabulary he has mastered? Without the recall of the meaning of certain conventional symbols and rules of action, how far will he get in the interpretation of a blue-print or the construction of a mechanical model.

[12]Pp. 10, 11.
[13]Op. cit., pp. 10-11.

In practically every instance of rational behaviour the element of recall is found to be indispensable, and from this point of view, memory must be granted a place as a most important factor in rational thought and behavior.

The two attitudes toward memory, then, are not necessarily in opposition to each other, because they do not have reference to the same thing. If a single, definite interpretation of *memory* could be agreed upon by both factions, there is no reason to believe that the apparently opposed views would not be virtually reconciled. Certainly we find it necessary to make use of our past experiences in all learning. All mental experiences must be interpreted in the light of past experience; after the first few "gasps of consciousness" in the life of an infant, nothing is entirely new to him; all things are learned through apperception, and apperception implies recall. On the other hand, it is undesirable, as well as unnecessary to have the student cram his mind with a heterogeneous mass of unrelated, unassimilable, random facts, of which there can be no psychological "cue" for recall, for these will be worse than useless.

There are, then, two kinds of memory which are sharply opposed and we must clearly distinguish between them. There is the memory which is a *jumble* of facts, and there is the memory which is a carefully arranged and catalogued *organization* of past experiences, so ordered as to be available for recall under appropriate circumstances. The first of these has no legitimate place in the educative scheme; the second is indispensable to effective learning.

Specific Types of Memory.

We may go further, however, than the separation of memory, in this broad way, into two classes, the one desirable, the other not. Upon closer scrutiny, a number of more or less distinct and specific forms may be identified. These fall broadly into three general groups which, for want of precedent and better classification, we may think of as comprising, (a) the rational types, (b) arbitrary types, and (c) miscellaneous types. Further sub-classification is unnecessary in this connection and will not be attempted.

Rational Types.

The rational types of recall are those resulting from such a foundational basis of associations as will be likely to insure proper functioning in appropriate situations. In the first place there is what we may designate as *sheer recall*. This takes place

by direct, active effort. It depends upon calling up circumstances known to have been associated with the experience which one desires to call to mind, in the effort to get a psychological "cue" to that experience. Very closely allied to *sheer recall* is a type which we may call *reflective recall*. The preparation for this is implied in a quotation from Schultze,[14] regarding methods of study:

> ". . . Another person will read little but will meditate upon the subject. He will try to associate the unknown with the known; will attempt to solve, as far as possible unaided all problems involved, and hence he will look at the subject from all sides."

Reflective recall is the product of an *organization* of ideas, consciously built up by analysis of a situation, and *with a view to later application*.

In order to discriminate between this and a type which may be spoken of as a *rational associational recall* we have to make a close distinction, and that in the preliminary, association-forming stage. Whereas *reflective recall* results from the association of experiences *with a conscious recognition of purpose, rational associational memory* is the product of the same sort of association *made incidentally*, or *without* consciousness of purpose. Such a type of recall presents different elements of a situation in their proper relation to each other and is thus indispensable to effective rational thought.

Thus far we have spoken of *conscious* types of rational recall. There is another kind, however, which is of vastly more importance than we ordinarily realize. This is the sort of memory process that goes on without effort, and often, indeed, without the conscious realization of remembering. Hence we may speak of it as *habitual recall*. The geometer does not have to stop and *consciously remember* the significance of the symbolism by which he designates the various parts of his geometrical creations. Through constant application[15] and association, the significance of a, b, c, and x, y, z become "second nature" to the algebraist; and E, I, and R require no translation in the mind of the student of physics who has been working with Ohm's Law. One sees the face of a friend, and it is not necessary to stop and ask oneself, "What is his name?" Thus *habitual recall* is a most important factor in all our reactions to all sorts of *familiar* experiences.

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[14] Op. cit., p. 9.
[15] *Talks to Teachers*, p. 133.

In the same way there is a corresponding habitual reaction resulting from the habitual recall of former reactions under given circumstances. Our habits of doing things are essentially of the same nature as our habits of thinking things. To illustrate: If a class in algebra has been working for some time upon problems of a certain type, a definite form of attack will be evolved, and when the same type of situation comes up later, this form of reaction will come into evidence again. We may speak of it as the result, or the expression in terms of behavior, of an *algoristic* type of recall.

There is still one further type of rational recall which we find it hard to name. The reference is to the inclusive recall of all elements and characteristics of a situation, and is prerequisite to the elective thought which characterizes abstraction. Perhaps the mere term *comprehensive recall* may serve to designate it. Following this cue, there is also a *conceptual memory*, a recall of the interpretation of abstractions, which is entirely dependent upon rational thought and association.

Arbitrary Types of Memory.

We come now to the *arbitrary* types of memory. These include such forms of recall as are not specifically prepared for some sort of rational scheme of association of experiences.

They require little comment beyond mere enumeration. Frequently the mind retains with great vividness and detail particulars sensory experiences. This is especially true with reference to the auditory and visual senses. There probably will be no rational association of such experiences with contemporary circumstances, and this lack of conscious association not infrequently makes the calling into action of these visual and auditory types of memory difficult, if not impossible. Yet the memories certainly exist as potential things, and as such must be given recognition.

There is another type that must not be overlooked, for it is very important in many phases of learning. This may be called the *arbitrary associational* type, or the *mnemonic* type. It has some characteristics of both rational and arbitrary memory. The association is consciously made, and, so far as possible, organized into some sort of schematic device, and to this extent it savors of the rational. On the other hand, the elements to be associated have no organic relation, and the association is purely an artificial one. The artificiality is consciously realized, even while the association is being made. For this reason

mnemonic memory is classed as an arbitrary, rather than a rational type.

There is a fourth sort of arbitrary memory: A sheer, parrot-like repetitive recall of words, with little or no undertsanding of the contest. Where is the high-school student of geometry who has not, at some time or other learned his demonstration by rote, or the latin student who has not memorized, verbatim, the translation given by a friend? This is the type of memory to which Schultze objects in his criticism of memorizing as an element in the study of high school courses[16].

Miscellaneous Types.

Memory, like many other things, is subject to wide and inexplicable individual variation, and appears in certain individuals in ways totally at variance with normal types and legitimate expectation. There are individuals, for example, who possess peculiar idiosyncrasies or tricks of memory. An example of this is the existence of so-called "number-forms."[17] Again, consider the mysterious power, native to other individuals, of recalling exactly long lists of names or dates or complicated systems and columns of numbers. This is the type of memory possessed by the prodigy.

The *photographic* memory is another of these miscellaneous types. In a very limited application of the term, it is probably more common among children than among adults, because the latter have become prone to disregard certain phases of experience, while little children have not learned the power of discrimination to the extent that it will preclude their paying attention to all aspects of a situation. A photographic memory, with its great content and assortment of experiences, is quite as likely as not to have these in somewhat of a tangle. Now and then an individual is found, whose memory, in addition to possessing all the rich and varied content of a true photographic memory, has also a vast and complex organization and classification of this content. We may properly speak of this individual as possessing an *encyclopedic* memory. Interesting as they are, these miscellaneous types of memory are of such comparatively rare occurrence as to be of minor importance in the aggregate of all types.

Conclusion.

It is difficult to give a satisfactory summary of this chapter.

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[16] Op. cit., pp. 10, 18.
[17] See Angell, op. cit., p. 243.

Without attempting to summarize, however, we may call attention again to the order in which the discussion has been taken up, with the hope that this may help the reader to see the essential unity in the apparently diverse aspects of the problem. The physiological psychology and the functional psychology of memory are prerequisite to an understanding of its basic nature, while a discussion of the attitudes of educators toward memory in the learning processes is supplemented and elucidated by the section on specific types. The whole is necessary for our further endeavor in Chapter III, to relate memory to the forms of experience, which are encountered in the study and teaching of algebra.

(*To be continued.*)

GAS IN 1920.

Although the gas-making industry had great difficulty in obtaining adequate supplies of good fuel in 1920, the quantity of gas sold was greater than ever before, amounting to nearly 500 billion cubic feet, having a value of more than $300,000,000, according to the United States Geological Survey, Department of the Interior. The sale of by-products by gas-making companies was also greater in 1920 than in any previous year. Over 100,000,000 gallons of tar, 55,000,000 pounds of ammonium sulphate or its equivalent, and nearly 125,000,000 gallons of light oil and other derivatives were the principal items among these by-products.

The average price of gas in 1920 was much higher than it had been for several years, averaging sixteen cents a thousand cubic feet greater for coal gas and water gas and five cents a thousand cubic feet greater for oil gas and coke-oven gas than in 1918.

USES OF GROUND TALC.

The quantity of ground talc sold by producers in 1921 was 106,900 tons, valued at $1,181,000, as compared with 178,500 tons, valued at $2,143,000, in 1920. A canvass of the producers made to determine the quantity of talc consumed in 1921 by different industries shows that the paper industry used 38 per cent of the total and that the average value was about $10.60 a ton. Most of the supply was obtained from Vermont and New York. The paint industry, which requires a high grade of talc, used twenty-three per cent of the total. Nearly all the supply was obtained from New York, and the average value was about $14.10 a ton. The roofing industry consumed eighteen per cent of the total and drew its supply almost entirely from Vermont. The requirements for talc used in this industry are not exacting, as is shown by the average value, which was only $8 a ton. The rubber industry used a large quantity of talc for filler and in 1921 consumed nine and one-half per cent of the total. Vermont furnished most of the supply, which had an average value of about $9.50 a ton. The textile industry used about four per cent as a filler for cotton cloth. The average value was about $9.40 a ton. Only two and one-half per cent of the domestic output was used for toilet powder, the demand for talc for that use having been supplied largely by imported material. California supplied most of the demand for domestic talc for this purpose, and the average value was $18.60 a ton.

THE DETERMINATION OF "g."[1]

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It is not the object of this paper to present a new method, or even to consider exhaustively the older methods of determining "g." That would require more time than I have at my disposal. What I hope to do is to indicate a way of getting better results from one of the well-known methods.

Of the various methods of determining "g," the simple pendulum method is doubtless the most widely used and perhaps, all things considered, the most generally satisfactory. I think it is the method students succeed best with and I also think it has within it the possibilities of great precision.

The quantities to be measured are two in number, the length of the pendulum, l, and the period, or half period, t, in the formula, $g = \pi^2 l/t^2$.

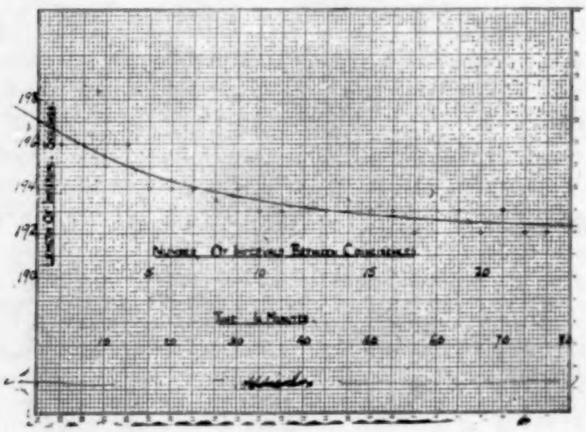

Figure I.

The length of a pendulum about a meter long can easily be measured to within one part in ten thousand, with a good cathetometer, if the pendulum is properly constructed, and if suitable corrections are made for the mass of the suspension and for the moment of inertia of the ball. If, then, "t" can be determined with equal accuracy, we should have no difficulty in getting the fourth figure in the final value of "g." However, "t" must be *squared* and must therefore be determined to within one part in twenty thousand in order that the value of "g" may be correct to within one part in ten thousand.

[1]Read before the Chemistry and Physics Section of the Illinois State Academy of Science at Rockford, April 28, 1922.

To count twenty thousand oscillations and guarantee the count would be rather too great a strain on human endurance, even if we could get a pendulum to continue swinging long enough, which would be another difficulty.

The coincidence method furnishes a perfectly splendid way of supplementing human endurance at this point, but our next difficulty lies in the fact that the oscillations are not strictly isochronous. Many of our laboratory manuals say they are practically so, if the amplitude of the pendulum is not more than five degrees. Well, that might do for measuring the period to within one part in a thousand but not for one part in twenty thousand.

This slide (Figure 1.) shows the interval between coincidences on the Y axis, plotted against the number of intervals on the X axis. It is obvious that as the number of intervals increases, that is, as the amplitude of the pendulum decreases, the length of the interval decreases.

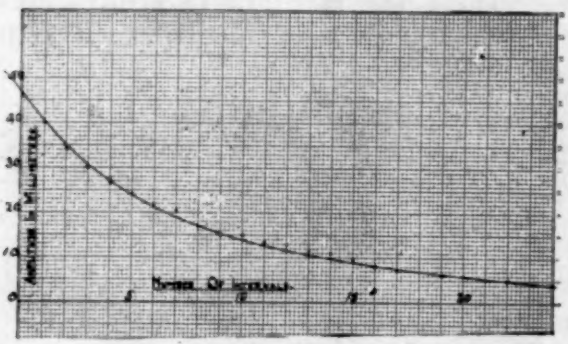

FIGURE II.

This is a case in which a pendulum a little less than a meter long ran an hour and twenty minutes, starting with an amplitude of 46^{mm} and finishing with an amplitude of 3.5^{mm}.

During this time the interval between coincidences decreased from about 197 seconds to about 192 seconds. Which value shall we accept? Neither of them, of course. The period is changing with the amplitude, and we really want the period for an infinitesimal amplitude.

However, the interval between coincidences approaches a minimum as the curve approaches a position parallel to the X axis. The curve *appears* to be nearly horizontal at the end of the twenty-fourth interval, but *just* how much farther it has to run, it would be difficult to say.

This slide (Figure 2) shows the decrement in amplitude for the same set of observations. The curves are quite similar in character. The next slide (Figure 3) shows the two curves plotted on the same scale, and when the two are placed side by side they are seen to be almost identical. It is obvious that the interval approaches a minimum as the amplitude approaches zero, or that the minimum on the interval curve may be taken at the X axis on the amplitude curve. In the case under discussion the amplitude curve is two spaces above the X axis at the end of the twenty-fourth interval. Since the two curves are so nearly identical, we may safely assume that the interval curve reaches a minimum two spaces below its position at the end of the twenty-fourth interval. This would be about 191.9 seconds, and with no very great uncertainty about the fourth figure.

Granting the possibility of an error of one or two units of the fourth order, let us see what the effect would be on the period. For an interval of 191.9, the period is 191.9 divided by 192.9 or 0.994816. For an interval of 191.8, the period is 191.8 divided by 192.8 or 0.994813, and likewise for an interval of 191.7, the period is 0.994811.

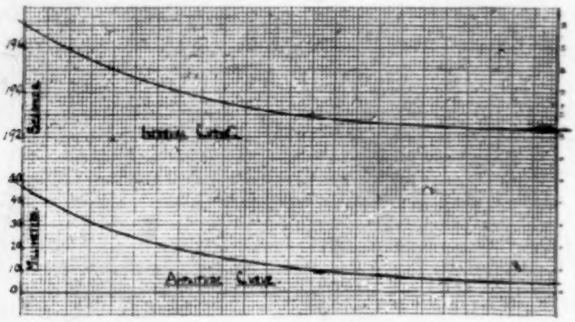

FIGURE III.

Of course there is no justification for carrying these numbers to six figures, but the calculations show that if the curve can be correctly placed to within one or two, or even to within three or four spaces, the values of "t" are correct to five figures. These results are alike to within considerably less than one part in twenty thousand.

Our measurements, then, are sufficiently exact, and we might expect results to within one part in ten thousand if there are no other sources of error.

There is, of course, a formula which corrects the period for

the amplitude of a pendulum, but who knows what other errors are to be corrected? For example, does the suspension bend exactly at the edge of the clamp which holds it, or does it begin to bend a little farther down? And if the suspension is very slender, does the weight of the ball stretch the wire more when moving with higher velocity than when moving with lower velocity, and if so, how much does this add to the length of the pendulum?

These questions are important if the pendulum is swinging through an appreciable arc, but they lose their significance entirely when the pendulum is swinging through an infinitesimal arc, and therefore, errors arising from such sources are entirely eliminated by the method here described of finding the minimum interval between coincidences.

Finally when all the errors are included, in measuring both the length and the period of the pendulum, in the hands of our students in Knox College, the method yields results ranging from 980.2 to 980.4.

The theoretical value of "g" for Galesburg is 980.26.

SOUND PROOFING IN BUILDINGS.[1]

By F. R. Watson,

Professor of Experimental Physics, University of Illinois.

The demand for quiet rooms in hospitals, hotels, and office buildings, the desirability of insulating music studios and other rooms where disturbing sounds are produced, have led to repeated requests from architects and builders for reliable information on effective methods for insulating sound. Although present knowledge of the subject is incomplete, nevertheless, on account of the pressing need for guidance in such matters, it is thought desirable to collect and present the available information in a systematic way, giving the methods and results of various investigations relating to the action of sound-proofing, and setting forth in accordance with existing knowledge recommendations that may be applied where sound insulation is wanted.

This introductory statement in a recent bulletin[2] on "Sound-Proof Partitions" indicates the lack of information on the subject of sound-proofing.

The action of sound in a building is much of a mystery to many people. There is a popular belief that wires stretched in an

[1]Read before the Chemistry and Physics section of the Illinois State Academy of Science, at Rockford, April 28, 1922.
[2]"Sound-Proof Partitions," Bulletin 127, University of Illinois Engineering Experiment Station.

auditorium will be of benefit for faulty acoustics, or, if this fails, that a sounding board over the speaker's head will remedy matters, Also, concerning sound-proofing in buildings, an impression prevails than an effective wall is one containing air spaces. These popular conceptions are not altogether supported by the facts. People who regard the problem with a degree of seriousness realize that the action of sound is not a matter of chance, but that the phenomena must accord with scientific laws.

In the bulletin mentioned, the results are given of a survey of the subject of sound insulation in buildings from three standpoints—the theory of the subject, experimental investigations and practical installations of sound-proofing. This information thus collected while drawn from different sources and apparently unrelated, proved quite concordant and led to conclusions concerning effective sound insulation.

Two Types of Sound in Buildings. Two types of sound should be considered in the problem of insulation in buildings. One type includes sounds that are generated in the air and that progress through the air to the boundaries of the room; the other is composed of compressions generated in the building structure by motors, elevators, and street traffic.

Insulation of Sounds in Air. Sounds of moderate intensity such as those generated by the human voice or a violin may be stopped with comparative ease if the walls of the room are continuous and fairly rigid. The more vigorous sounds of a cornet, trombone, etc., would require especially heavy walls or else double partitions. Any breaks in the walls for ventilators, pipes, or doors should be guarded by effective insulation.

Insulation of Building Vibrations. Compressional waves generated in the building structure pass readily along the continuity of solid materials, and, as they have more paths for escape, are more difficult to insulate than sounds in air. Moreover, they may create trouble when they cause a wall or floor to vibrate. The insulation is based on the same procedure as that used for air sounds; namely, to interpose a new medium differing in elasticity and density. An air space in masonry would be effective if not bridged over by solid material, but since this is impossible for ordinary building constructions as the weight of bodies necessitates contact for support, an approximate insulation is sought by using air-filled substances like dry sand, ground cork, hairfelt, or flax, that possess but little rigidity but are capable of sustaining a floor or a partition that is not too heavy.

Transmission of Sound. Sound waves in air may be transmitted through an obstructing medium in three ways. First, they may pass through the air spaces of a porous material. Second, they may be transmitted by modified waves in the new medium. In this process sound compressions and rarefactions progress rapidly through the air, moving the molecules successively as they pass in somewhat the same way as a gust of wind blows the separate stalks in a wheat field. On reaching a solid partition the forward motion is hindered, particularly if the molecules of the new material are massive and resist compression. In this case most of the energy is reflected and only a small proportion progresses through the wall. On meeting a further discontinuity of material, such as wood or air, the waves are again affected, until finally a part of the energy emerges. Third, sound may be transmitted by setting a partition as whole in vibration. The partition then acts as an independent source of waves, setting up compressions and rarefactions on the further side and giving a sort of fictitious transmission. If the partition is rigid and massive the vibrations are small and very little sound is transmitted; if the partition is thin and flexible a considerable amount of energy is transferred.[3] Usually in building constructions the partitions are complex, as for example plaster on wood lath and studding. In this case the plaster areas between the studding act in a manner similar to drum heads and transmit sound. Hard plaster on wire lath presents a different surface with a modified action on the incident sound.

The transmission of sound involves a number of phenomena and is not a simple matter. It depends essentially on the character of the structure through which sound is transmitted and can be calculated only for simple cases of homogeneous materials of known constants.

The systematic survey of the subject of sound-proofing as given in the Bulletin leads to several practical conclusions.

Ventilation System. Especial attention should be paid to the ventilation system. All effective sound-proof constructions either omit entirely a ventilation system or else construct it in some special manner to avoid transmission of sound. In some buildings air is supplied and withdrawn from rooms by individual pipes that are small in diameter and extend without break from the air supply chamber to the rooms. This results in considerable

[3]Rayleigh, Lord. *Theory of Sound,* loc cit. see also: Jager, G. *Zur Theorie des Nachhalls,* Sitzungber. der Kaisl. Akad. der Wissenschaften in Wien. Math. Natur. Klasse, Bd. CXX, Abt. 2a, 1911.

friction between the walls of the pipes and the air, with a resultant weakening of the sound waves. Without some efficient control of the transference of sound through the ventilation system it is a waste of effort to construct sound-proof walls, double doors, and other contrivances for insulation.

Sound Proof Partitions. Partitions between rooms should be as rigid and free from air passages as possible. For effective sound-proofing of a group of rooms, the partitions, floors, and ceilings between adjacent rooms should be made continuous and rigid. Any necessary openings for pipes, ventilators, doors, and windows should be placed in outside or corridor walls where a leakage of sound will be less objectionable.

Absorption of Sound. The absorption of sound is an essential feature for sound-proofing. Reflecting sound and scattering it still leaves it with energy. It must be absorbed; that is, converted into heat energy by friction, before it is eliminated as sound. This means that carpets, furniture, draperies, etc., should be present, or if greater absorption is desired, hairfelt or similar materials must be installed.

Sound-proofing a Building.[4] When sound-proofing a building all details should be considered with respect to the likelihood of transmission of sound. Each room, as far as possible, should be made an insulated unit by means of air spaces or air-filled materials that separate it from surrounding walls. Pipes and ventilators should be so installed as to minimize the chance of transfer of sound. Patent doors are now available that will close the door space at top, sides and bottom. In case a troublesome sound is generated in the room, it may be minimized by installing absorbing material on the walls.

The insulation of sound is a complex problem and a successful solution is obtained only when all the possibilities of transfer of sound are anticipated and guarded against. While many things may be learned from further experience and much may be gained from additional theory, enough has been revealed to give encouragement to the belief that sound-proofing may be prescribed in the future with some of the certainty that now attends the acoustic design of auditoriums.

[4]"Sound-proofing a Building," *Architectural Forum*, November, 1921.

RESEARCH IN PHYSICS

CONDUCTED BY HOMER L. DODGE,

University of Oklahoma, Norman, Oklahoma, Representing the American Physical Society.

The results of research in physics as a rule are published in special journals in the form of technical articles. It is difficult for the busy teacher to keep up with the progress of his science except through general articles and books. Unfortunately there are not many such books. It is the intention of this department to call special attention to those which come to its attention.

WITHIN THE ATOM.[1]

It is remarkable that John Mills, the author of *Within the Atom*, should have been able to compress into the compass of one small volume such a readable and complete summary of the discoveries of modern physics. To review this book by the method previously employed is impossible. Usually we have gleaned from a book the material for a short article hoping that the article itself would be of value and at the same time would give a correct impression of the character of the work. *Within the Atom* does this for the literature of modern physics and to attempt to re-distil such a splendid distillate would be entirely out of place. Consequently we shall attempt merely to give an idea of the nature of the work and suggest how it may prove of pleasure and value to teachers of physics.

The subtitle, "A Popular View of Electrons and Quanta," may easily be misinterpreted. Any layman who expects to find easy reading will be disappointed, but he need not feel deceived, for no more "popular" treatment could be found and remain sufficiently technical to be fair to the subject. Nor will the book be easy reading for the teacher of physics, for the more familiar he is with modern physics the more enjoyable and profitable will his reading be. The book will probably be more popular with teachers than the average reader.

The author shows very good judgment in abruptly plunging into the subject and introducing his audience to the electron and the proton on the first page. After personifying the two electrical elements sufficiently to overcome any feeling of strangeness on the part of the general reader he takes pains to emphasize the mechanistic side of this ultra microscopic world by using the terms tractate and pellate for the familiar attraction and repulsion of our text books.

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[1] *Within the Atom*, by John Mills. D. Van Nostrand Co., New York, 215 pp., illustrated. Price, $2.00.

In the first ten pages atomic number and radioactivity are touched upon and in the second and third chapters we find carefully laid out a physical basis for chemical action and the characteristics of the various elements. Finally the periodic table is given a vital meaning through an explanation so simple that any school boy, first wondering at the mysteries of chemistry as presented in the ordinary text book, would find many of them explained away.

The more familiar facts of radioactivity and conduction of electricity in gases are touched upon, followed by a most interesting chapter on conduction of electricity through solids and the simpler interactions and phenomena of electric and magnetic circuits. The writer of this review was particularly pleased with this chapter since he has found by experience that the introduction of the electron theory at the start in elementary courses makes the teaching of electrostatics and "current" electricity much easier for the students.

The chapter on the proof of the existence of the electron, including references to the early pioneer work of Thomson and the latter accurate determinations of Millikan, is followed by a chapter on the isolation of the proton or positive unit of electricity. Here is found a discussion of Wilson's photographs of the traces of beta and alpha particles, Thomson's positive ray analysis, Moseley's X-ray spectra, and Rutherford's bombardments of atomic nuclei.

To X-rays, crystal structure, and atomic numbers are devoted two chapters, after which the author plunges fearlessly into the quantum theory.

The appendix on the "Magnitudes of Electrons and Quanta" is a store of interesting data: The masses of hydrogen molecules, electrons and protons; the velocities of alpha and beta particles and quanta (or light); the energy of quanta, of gas molecules and electrons, etc. It is very useful to have such figures collected for ready reference.

In high school and college texts the electron and the new physics has been given a place in the regular reading matter and no longer is relegated to footnotes, small type or an appendix. However, the means by which the teacher who has not had the privileges of recent intensive study can keep adequately in touch with the rapid progress of physical science have not been good. While *Within the Atom* cannot take the place of special treatises it serves the desirable purpose of making a wealth of useful material available in a form especially adapted to the busy teacher.

COMPLETION TESTS IN PHYSICS.

By Edward L. Thorndike.

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Supplying omitted words in statements about physical facts and laws is a useful adjunct to the ordinary forms of examination question. If the statements are fairly well chosen and the omissions fairly well planned, even a short test (sixteen sentences graded from easy to hard, to be done in thirty minutes) correlates nearly or quite as well with general ability in physics as any test of equal length. Such tests discourage evasive wordy answers. They make a change from the organization of knowledge in the form of answers to questions asked by the book and in the class. The scores given are less subject to variation among different scorers than the scores given to ordinary paragraph answers. If keys are devised, rating typical completions as 3, 2, 1 or 0, the scores are almost as objective as those given for numerical problems in physics.

It is for many purposes better to use stock series of sentences in such tests than to make them up separately in each school. The advantages of convenience and of comparability with results attained in other schools are obvious. So I have prepared twelve such series, and one to use as a practice form to acquaint pupils with the nature of the test. I hope that some teachers of physics will find it worth while to extend the series to thirty or forty. If forty such series were available, they could even be made public to students without much harm being done. The best way that a pupil could "cram" for the 640 completions would be to get a sound knowledge of physics!

Memorizing the material without understanding it would be a very long, and perhaps impossible, task; and could be heavily penalized by using some sentences in which the addition of *not*, *never*, etc., and changes of *up* to *down*, *square* to *square root*, *direct* to *inverse*, etc., required a totally different completion from that which memory of the original supplied.

The twelve sets presented here were prepared as follows: Statements were collected and words omitted such as seemed to make tasks requiring desirable knowledge and power. These were roughly graded in an order from easy to hard. They were then arranged in sets of sixteen, so that any one set would on the whole be of roughly equal difficulty with any other to pupils

taught as they are now in high schools in general. Some of these sets test ability in the main within a single topic. Some of them are miscellaneous. The 192 sentences can be re-arranged in twelve sets each restricted in the main to one topic, by anybody who so desires. If each set includes one No. 1, one No. 2, one No. 3, etc., from the sentences as they stand, any twelve sets will be roughly equal in difficulty.

I regret that I cannot present measures of the exact inequalities in difficulty of these twelve sets or data showing the scores made in representative schools. All that I have done in the actual use of the tests is to take one at random to measure their significance. In this respect they are satisfactory, the correlation against a criterion of total ability in physics being, as stated earlier, as close as for any test of equal length.

These tests can be given with a generous time allowance so as to use fully whatever abilities the pupil has, or with a short time so that the readiness of his knowledge counts heavily. More than 40 minutes and less than 15 minutes are almost certainly unwise. Teachers of physics will be suspicious of the speed factor, though it is by no means certain that two sets at 15 minutes each will give a poorer measure of ability than one set at 30 minutes. Since, however, the teacher's time in scoring is of consequence as well as the pupil's time in taking the test, and since much emphasis on speed seems *a priori* undesirable in examinations in science, a time limit of 30 minutes per set seems the best. One-fourth of a two-hour examination may profitably be spent on such a completion test.

THE I. E. R. PHYSICS COMPLETION TEST
FORM 1.

WRITE YOUR NAME HERE..

Read the statements below. Write words (or numbers) in the empty spaces so as to make them true statements of facts and laws of physics. Read each sentence or paragraph all through and think what words are needed for it before you write any in. Then write them in. Then go on to the next number.

1. 100 centigrade degrees equal.................Fahrenheit degrees.

2. The angle..........................is equal to the..................................incidence.

3. ....light is a mixture of all the colors of the spectrum, from ....to...................................inclusive.

4. Surfaces which are........................absorbers of ether radiations are also.......................radiators. From this it follows that surfaces which are ....reflectors, like the polished metals, must be.......................... radiators.

5. The mechanical advantage of a system of pulleys, provided no energy is dissipated inside the pulleys, is .... the number of.............................of the cord supporting the load.

6. When a mass of air is heated..., its volume increases...........................of its value at 0 deg. C. for every rise of 1 deg. C. in temperature.

7. The periods of.............................of...............................lengths swinging through short arcs are...............................the weight and materials of the bobs.
8. The perriods of pendulums are...to the ....their lengths.
9. The coefficient of expansion of air is the ratio of the increase in volume produced by... to the original volume. Its numerical value is..............................
10. For the inclined plane the mechanical advantage, where the force is applied...............................the plane, is the............................. ....the length.....................the height of the.....................
11. The fundamental of an open pipe has a................................... equal to.............................the pipe length.
12. Two beams of light from the same source may be made............... ....so as to...and produce...............................called "interference fringes."
13. When a volume of gas at any pressure expands....................against normal atmospheric pressure, 0.024 gram-calorie of heat is converted into work.
14. A continuous spectrum is formed by incandescent.....................A bright-line spectrum is formed by incandescent...................................A dark line spectrum is formed by an... shining through an absorbing layer of...............................gas.
15. Radiant heat is, then, the radiated energy of...............................of ....wave lengths.
16. The resistance of a fluid to the motion of a body passing through it is... speed of the body.

FORM 2.

1. Watts...............................times...
2. ....electrostatic charges....................each other and............ ....attract.
3. A...............................may be polarized by the influence of a neighboring...............................body.
4. Current flows *downhill*, from + to −, in...
5. Current is pumped *uphill*, from − to +,...
6. A stretched string vibrates as a stationary wave in some.................. ....of loops, with nodes at the ....
7. Water waves are therefore called...............................waves, while sound waves in air are...............................waves.
8. The wave length of a sound may be more accurately defined as the distance between two...............................points of maximum.................. ....
9. Unit of...............................is ampere. Corresponds to............................. in water flow.
10. Unit of...............................is ohm. Corresponds to............................. in water flow.
11. Unit of...............................is volt. Corresponds to.............................in water flow.
12. The tendency of any liquid surface to act like a............................. membrane is called surface tension.
13. Liquids rise in...............................when they are capable of............ ....them, but are depressed in....................which they.................. ....
14. The frequencies of the three notes of a major triad are related by the ratios...
15. The interval between...............................is defined as the.................. of their frequencies.
16. The mechanical advantage of a machine is the...............................by which the...to get the resistance.
17. The force required to give a....................*m* a...............................*v* in *t*...............................is...............................the mass and to the............ ....and...to the time.

18. The force of gravity acting on a minute amount of liquid is...its own cohesive force.

19. From testimony of this kind one is led to think (1) that sound consists of a..............................in..............................., (2) that the motion of the particles of air is..................................in the.........................direction ....that in which the sound is traveling, (3) that this.......... motion can be......................................, and (4) that two trains of sound waves may....................................to produce stationary sound waves.

FORM 3.

1. ....charges attract each other.

2. The transmission of..............................is effected only through the agency of ordinary matter.

3. The pitch of a musical note depends simply upon the.......................which strike the air per...

4. An electromotive force is induced in a conductor whenever it ....magnetic lines of force.

5. On making the current in the primary coil the current...................the secondary is..that in the primary.

6. At.........................the current induced in the secondary is...as that in the primary.

7. If the right hand is placed against the coil with the thumb pointing in the direction of the......................................the fingers will pass around the coil...

8. The pitch of a note depends simply upon the.............................of the vibrating body which produces it; or, what is the same thing, upon the..................................of the vibrating body.

9. The frequency of a vibrating body is simply the..............................of...

10. Only those sounds possess a.....................................quality which come from sources capable of sending out pulses, or waves, at..intervals.

11. The resistance of a wire is proportional to its...............................inversely proportional to the.., and depends on the...

12. A.............................has a........................of 1.........................when it deposits from a solution of a silver salt 0.001118 grams of silver per second.

13. The direction of the..................................meridian varies from one point to another on the earth's surface.

14. The frequency of a note from a string vibrating in a single loop is......................................to the.....................................of the string.

15. A wave length is the.......................................distance between any ....whose motion is in the same phase.

FORM 4.

1. That kind of electrification which appears on sealing wax or gutta-percha when rubbed with flannel is called...

2. The unit of..................................is the volt. The.....................................of a gravity cell is 1.08 volts.

3. Discord is simply a phenomenon of......................................

4. Any portion of the vibrating string which lies between two............nodes is called a loop. The..................................of a loop is called an antinode.

5. Any two..........................substances, when brought into intimate contact and then separated, acquire.....................charges of.................signs.

6. Liquids rise in capillary tubes when they are capable of.................but are depressed in tubes which...

7. If the......................hand grasps the wire so that the....................points in the direction in which the current is flowing, then the magnetic lines encircle the wire in the same direction as do the............................

8. When a conductor is brought near a charged body, the ....

away from the.................................is electrified with the..................... kind of electricity as that on the.................................body, while the end...........................the inducing body receives electricity of..................... kind.

9. When several equal resistances are placed in.........................., their total or joint.................................is equal to the............................. of one of them,...........................their number.

10. In order that a body be set.................................by resonance, the.................... of the impulses given it must be .... its own natural .... of vibration.

11. The .... of the overtones of an .... organ pipe are related to that of the .... by the ratios 1:2:3:4:5, etc.

12. The note emitted by a string plucked at random is a complex one, consisting of a..........................and ...., and just what overtones are present in a given case depends on .... and .... the wire is plucked.

13. It will be found in every case that resonance occurs between vibrating bodies only when their .... are approximately equal.

14. The vibration numbers of similar strings of equal length are proportional to .... of the tensions.

FORM 5.

1. The .... is a great magnet.

2. In the voltaic cell energy is supplied by chemical action of acid on .... is fuel of a cell.

3. We may, therefore, define a .... as a state of disturbance propagated from one part of a medium to another.

4. The .... the frequency of a tone, the .... its pitch.

5. The pressure of a gas heated at constant volume is proportional to ....

6. The amount of work that can be done by an expanding gas is proportional to the .... through which ....

7. The speed with which a wave travels is found by...................... the .... by the frequency.

8. The .... the field, the .... the number of lines of force.

9. Magnetism is a .... property.

10. In an ammeter—low resistance—put in ....carries .... current.

11. Pressure:— .... freezing point of.................... 0.0072° C. per atmosphere and .... boiling point of .... 0.037° C. per millimeter of mercury.

12. Latent heat of melting = heat absorbed during melting,
= heat yielded during freezing.
Latent heat of vaporization = ... during evaporation, or the ....during condensation.

13. The resistance of .... to the motion of a body passing through it is proportional to ....speed.

14. When a mass of air is heated ...., its volume increases ....of its volume at 0° C. for every rise of 1° C. in temperature.

15. Every motor, when running, is acting at the same time as a .... The .... of this ....action .... the .... driving the motor, and is the back ....

16. Ohm's law applies to a motor .... only if .... is used.

17. The electro chemical equivalent E is numerically equal to the .... of any element .... by the passage of one .... of electricity through the ...., while the .... of E is the .... of ....associated with one .... of the element in question.

Form 6.

1. Relative .... of objects are determined by the visual angle.
2. Waves transmit .... from one place to another.
3. Discord is .... by relating the .... of two tones so that there are no disagreeable beats when the tones are sounded together.
4. The frequencies of the .... of a string are related to that of the .... by the ratios 1:2:3:4:5: etc.
5. When cells are connected in series, both their .... and their .... are added together.
6. By means of the .... and the .... the electric current may be made to do mechanical work.
7. Other things being equal, the total force of friction between two surfaces is proportional to ....
8. The resultant of two .... forces is equal to the sum of the two forces.
9. The .... the number of .... force cut per ...., the greater the ....
10. If the coil is grasped in the right hand in such a way that .... the direction in which the current is flowing in the wire, the .... in the direction of the .... pole of the helix.
11. In an ....:—Frequency equals .... per second times number of .... A. C power equals amperes times volts times power factor. Power factor usually less than one.
12. Volts times .... times .... equals joules.
13. The resultant of two forces is defined as that .... which will produce the .... a body as .... by the joint action of the ....
14. Graphic representation of force. A force is completely defined when its ...., its ...., and the .... are given. Since the three characteristics of a straight line are its ...., its ...., and .... it is obviously possible to .... forces by means of ....
15. The particles of the elastic medium in which waves travel do not move .... with the waves; each one merely .... over a small .... on either .... of its .... of rest.
16. Interference is, therefore, employed in physics to denote the combination of waves in any .... of .... whatever.
17. The .... of .... in air .... 2 feet per second for every degree C. rise in temperature.

Form 7.

1. Sound, in physics, is a .... motion transmitted through .... or other ...., ..., ...
2. Velocity of .... is about 1100 feet per second. (Accurately it is 1087 feet /sec. at 0° C. and it increases about 2 feet, /sec. for each degree C. rise.)
3. Wave length equals distance from .... to .... or from .... to ....
4. Waves are transverse when the particles of the medium vibrate .... the direction in which the .... travels and longitudinal when the particles vibrate .... direction in which the ....
5. Magnetism produced by the mere presence of adjacent ...., with or without contact, is called .... magnetism.
6. Power delivered to circuit equals .... current times ....

7. When the motion of the particles in the medium is .... the direction in which the .... travel. Such waves are said to be transverse. When the displacement of .... is lengthwise, such waves are called longitudinal.

8. When no external influence is at work, the .... of any body ....

9. When an external force is at work, ... of linear momentum is .... the force and takes place .... the force acts.

10. It is sometimes possible, by applying a small ...., to overcome a much larger .... The ratio of the .... to the .... is called the mechanical advantage of the machine.

11. Resonance is the .... of sound because of the union of .... and .... waves.

12. Wave length is equal to .... divided by .... per second, or .... is equal to the number of vibrations per second .... the ....

13. When a current of air is suitably directed across the mouth of a closed pipe, it will emit a note which has a wave length.................... the length of the pipe. This note is called the fundamental of the pipe It is the .... which the pipe can be made to produce.

14. Concurrent forces are .... when their .... is zero.

15. The force (resistance) which one can obtain by use of the wheel and axle is to the .... which he applies (effort) .... as the .... of the wheel and of the axle. Since .... (r_1 r_2), ...(d_1 d_2).................... are in the same ratio, ... or .... may be used instead of ....

16. Whenever light travels .... from one medium into another in which the .... is less, it is bent ...., and when it passes from one .... to another in which the .... is greater, it is bent .... drawn into the .... medium.

Form 8.

1. The .... produced by two tones is equal to the difference in their frequencies.

2. The length of air column in .... pipe which gives the best response is approximately one-fourth wave length.

3. Harmonious musical intervals correspond to .... vibration ratios.

4. Magnetic quality .... at red heat.

5. The .... is the current which will deposit .001118 grams of silver in one second.

6. .... equals volts ....ohms.

7. This property, which all matter possesses, of resisting any attempt to .... it if at ...., to .... it if ...., or in any way to .... either the .... or the .... of its ...., is called inertia.

8. .... manifesting itself in the tendency of the parts of rotating systems to .... the center of rotation is called centrifugal force.

9. The intensity of a sound varies .... as the .... of the .... from the source.

10. The .... of a cell equals total pump action in cell.

11. Terminal voltage equals .... between terminals. The terminal voltage is .... e. m. f. by amount needed to keep current moving through .... of cell.

12. If a loop of wire, free to turn, is carrying a .... in a .... field, the loop will set itself so as to .... as .... as possible of the .... of the field.

13. In a ....:—

$$\frac{\text{Voltage on primary}}{\text{.............. on secondary}} = \frac{\text{.................... primary}}{\text{.................... secondary}}$$

14. The resultant of any number of parallel force is their .... and its point of application is the point about which .... of moments is ....

15. Force produces .... linear momentum.

16. Force is measured by .... of .... hence $F = mv/t = ma$.

17. Rotational inertia depends not only upon the .... but also upon the ...., of the mass, namely, its .... rotation.

18. Parallel forces are in equilibrium when the .... of the .... is zero and also the .... of their .... about .... is zero.

FORM 9.

1. A compass needle tends to set itself .... a wire carrying an electric current.
2. The .... is the unit of electrical power.
3. A motor transforms .... energy into .... energy. A coil of wire wound on an .... is an electro-magnet.
4. All bodies can be electrified by ...., becoming charged either .... (vitreously) or .... (resinously).
5. The space about a .... body over which it is able to exert .... is called its electric field.
6. Current is carried through cell by charged ....
7. Any .... in the number of .... which thread through a coil induces a current in the coil.
8. A current in a magnetic field tends to move .... the side on which its lines of force are .... those of the field.
9. The force which one .... particle exerts upon another depends upon the .... in which the particles are situated, as well as upon the .... between the particles.
10. Apparently any charged body is able by .... to sort out from an uncharged body .... and .... charges, ... those charges that are .... its own to the side nearest itself and .... those that are ....
11. The .... within the cell, as well as the ...., offers .... to the .... of the current.
12. In general, the ratio between the .... at the terminals of primary and secondary is the ratio of the .... upon the two.
13. The repulsive or .... force between two quantities of .... is directly proportional to the .... of the two quantities. .... quantities of electricity can always be obtained by exactly duplicating any process which produces electrification.
14. Self-induction appears *only* when the .... is ....
15. The forces of attraction or repulsion, of electrical charges are found, like those of .... and ...., to decrease as tne .... increases.
16. Cathode waves are streams of .... shot off from the surface of the .... with speeds which may reach .... per ....

FORM 10.

1. Like magnetic poles .... each other; unlike ....
2. In a voltaic cell, the chemical action develops an .... which drives the electric current through the circuit.
3. The current flows in the .... from copper (or carbon) to zinc.
4. The ...., is the quantity of electricity required to deposit .001118 gram of silver.

5. Magnetic lines of force tend to .... and ....; that is, there is .... along them, and .... at right angles to them.

6. The E. M. F. of a galvanic cell depends simply upon the .... of which the .... is composed and not at all upon the ...., ..., or .... of the plates.

7. For resistances in parallel:

The total current through the combination is .... currents through parts.

The .... of combination is .... of conductances of parts.

The .... across conductors is the .... for all.

8. With constant ....,................., the smaller the ...., the greater the current strength.

9. The earth is a magnet with its .... pole at Peary's end.

10. To magnetize a piece of iron, we need not .... it with a ....; we need only bring it into the neighborhood of a ...., i.e., into a magnetic .... This process is called magnetic ....

4. At a given instant the number of .... of current flowing is .... through every complete .... of a given circuit.

12. A condenser consists of two plates of metal with a thin layer of .... between them. It has a .... capacity for .... electric charges.

13 The effect of self-induction is always to .... the .... of the current.

14. Since electrification is produced by such slight means, we are led to think that any two .... substances brought into .... become electrified.

15. Whenever a current is induced by the .... motion of a .... and a conductor, the .... of the induced current is always such as to set up a .... which .... the ....

16. Electrical oscillations set up waves in the .... These waves are known as .... waves.

Form 11.

1. Current equals .... divided by ....

2. The zinc is always the .... electrode of a cell.

3. The potential difference between two points on a circuit is .... to the resistance between those points.

4. A coil carrying an .... is surrounded by a magnetic field of force and acts exactly like a ....

5. One may charge a body, provided this body be a .... by simply bringing it into the field of .... body.

6 The resistance of any conductor is directly proportional to its .... and inversely proportional to the ....

7. Thumb rule for *straight wire:* Use .... hand. *Thumb* points .... *Fingers* curl ....

8. With constant ...., the greater the .... the greater the current strength.

9. It was shown by Cavendish and Faraday that the force which one .... particle exerts upon another depends upon the material of .... which separates them. This .... material is generally called the medium, or the ....

10. Ohm's law applies to a whole ...., or to .... of a circuit. If it is applied to a whole circuit, we must take account of the .... of ...., as well as of .... of the wire.

11. For cells in series:

The e. m. f. is .... e. m. f.'s of parts.

The .... is .... resistance of parts.

The current is the .... in .... as in ....

12. Iron has great .... for lines of ....force.

13. The currents furnished by different galvanic cells, or combinations of cells, are always directly proportional to the .... existing in the .... in which the ...., and inversely proportional to the .... of these ....

14. A substance may be .... with electricity by .... it with another substance. Its .... is then .... that of the earth.

15. The .... of the capacity represents by .... with the pendulum spiral and other .... systems, the electrical .... of the circuit.

16. The .... of a substance deposited by a .... equals electro chemical equivalent times .... times ....

Form 12.

1. The north-pointing end of a magnet is called the .... pole, and the south-pointing end is called the .... pole.

2. A magnetic field is filled with .... of magnetic force.

3. A .... electrified body is one which acts with respect to other electrified bodies like a glass rod which has been rubbed with silk, and a .... electrified body is one which acts like a piece of .... which has been rubbed with ....

4. Electric currents .... only in completely .... conducting circuits.

5. Slip rings give .... current. Commutator gives .... current.

6. For resistance in series:—The current is everywhere the .... The .... of the combination is .... of resistances of parts. The .... across combination is .... of voltages across parts.

7 .... of .... around a straight current are concentric circles.

8. In the northern hemisphere, the .... end of a compass needle dips down; in the southern hemisphere, the .... end dips down.

9. In a voltmeter .... resistance put .... circuit-................ current.

10. The force which one charged particle (or body acting as a particle), exerts upon another varies .... as the .... of the .... separating the bodies.

11. For cells in parallell:—The e. m. f. is .... e. m. f. of .... The .... of n cells in parallel is $1/n$th the .... of any one alone. The .... in each cell is $1/n$th the .... in external circuit.

12. A dynamo does not .... energy; it .... mechanical into .... energy.

13. The .... is the .... at 0.° C. of a column of pure mercury 106.3 centimeters long and one square millimeter in cross-section.

14. If the .... charge of a polarized .... be grounded, and if first the ground connection and then the influencing body be ...., the .... remains .... with an amount of electricity .... and .... that of the influencing body.

15. A wire carrying a .... in a magnetic field tends to move in a direction .... both to the .... the field and the .... the current. This fact underlies the operation of all ....

16. The spark discharge of a condenser .... very rapidly and is capable of starting the .... waves used in ....

Form 13—Practice Form.

1. Light generally travels in .... lines.
2. Sound is transmitted by .... waves in ....
3. That kind of electrification which makes its appearance on glass

when rubbed with silk is called ....

4. Bodies may be .... by induction.

5. The direction of the current through the external circuit is always from the .... to the .... pole.

6. When we look along a wire in the direction in which an electric current is flowing, the .... pole of the needle near the wire is deflected .... in which the hands of a clock move.

7. The speed of the waves depends upon two quantities only; viz. the .... and the linear density (i.e. .... per unit ....) of the vibrating cord.

8. The .... is the electrical pressure required to drive a current of 1 ampere through a .... of 1 ohm.

9. .... bodies possess energy .... of their motion.

10. The mechanical advantage of a composite machine is the .... of the mechanical advantage of its parts.

11. .... is measured by the .... of the mass and the velocity.

12. The earth's action on a .... is a couple.

13. An induced current exists *only* when the .... of .... through the circuit is ....

14. The shortest resonant length of an open pipe is .... wave length, and there is .... at any .... of .... wave length.

15. The surface of a body of water at rest, for example a pond, is at right angles to the .... force, that is ...., which acts upon it; and second, the force of gravity acting on a .... liquid is .... in comparison with its own .... force.

16. To find the component of a force in any given direction, construct upon the given force as a diagonal .... the sides of which are respectively .... and .... to the .... of the .... The .... of the side which is parallel to the given direction represents the .... the component which is sought

17. Waves will not travel in a medium unless it has both .... and ....

A STUDY IN AN AMERICAN DESERT.

One of the driest parts of the United States is what is called the Papago country, a region including about 13,000 square miles in southwestern Arizona, so called because it was long ago inhabited by the nomadic Papago Indians. This broad expanse of desert country, which lies between Gila River and the Mexican boundary, contains many groups of volcanic and other mountains separated by broad alluvial basins, which, though the rainfall is small and the temperature is high, sustain a scant growth of desert plants, including orchard-like groups of strange trees. Here the bold slopes of the mountains, the general absence of watering places, and the peculiar forms of the vegetation impress the traveler strongly with the majesty and the mystery of the desert, and excite his wonder as to the origin and history of the natural features.

A report on this region by Kirk Bryan has just been published by the United States Geological Survey, Department of the Interior, as Bulletin 730-B, under the title "Erosion and Sedimentation in the Papago Country, Arizona." The report describes the geology briefly as a setting for a consideration of the agencies that have produced the forms of the land and presents detailed conclusions as to the mode of origin of the desert landscape. The paper is illustrated with diagrams, views, and maps and should be of interest to all students of topography and physiography, particularly those who are endeavoring to solve problems of erosion by wind and water in desert regions.

THE TANGENT OF 2X.

WILLIAM F. RIGGE,
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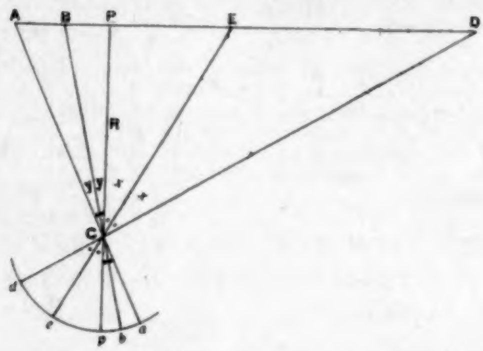
The object of this article is to show an interesting and practical application of one of the well-known formulas of trigonometry that appear to be so dry and valueless to the student who must memorize them, and so purely theoretical and pedagogical to the instructor who exacts them. It is the formula $\tan 2x = 2\tan x / (1-\tan^2 x)$. This can be used to find the focal length as well as the position of the camera in certain cycloramic pictures. The essential element of this picture must be a straight wall of some kind or its equivalent, or at the very least, certain five points that we need must be in a straight line, such as the



points, A, B, P, E, D, in the diagram, and this line must be so placed that it will contain the foot of the perpendicular P dropped to it from the camera C. With this requirement we combine the fact that, as the camera lens revolves, equal fractional lengths of the film will correspond to equal horizontal angles in space, the exact proportion being unknown at the start. These two, the straight wall and the equiangular film, will solve the problem.

1. The first step in the proceeding is to find the point P on the wall by means of its image on the picture. In order to do this without defacing the original photograph, it is advisable to cover it with transparent paper and make our marks on that. As all horizontal lines in space become sine curves on the film of a cycloramic camera, the nearest portion P of the wall is the vertical line passing through the highest points of the sine curves. To locate this vertical line more accurately, it will be well, by means of an adjustable curve ruler, to supply on the

transparent paper the breaks in the sinusoids, such as the spaces between windows. Then we draw a horizontal line on the paper, note its points of intersection with a sinusoid, bisect the distance between them, and draw the vertical line P through this bisection. The photograph that was actually used in solving this problem is not reproduced here, because it is rather long and dark and its parts would suffer too much by reduction. It represents a group of students standing before the east front of the north wing of Creighton College in Omaha.

2. The second step is to measure off from P equal horizontal lengths on the picture. In this case, by using a scale of fiftieths of an inch and estimating to tenths of these by means of a magnifying glass, the length $p\,e\,d$ on the film between the images of P and the north end of the building D, was found to be 8.532 inches. $P\,C\,D$ or $p\,C\,d$ is then a certain unknown angle, and $p\,e\,d$ its corresponding arc, which we will call $2x$. The point e on the film, halfway between p and d, is 4.266 inches from each. We note this point e very carefully on the picture, even to the fraction of a brick, as well as we are able. $P\,C\,E$ and $E\,C\,D$ are then equal angles in space, each equal to x.

3. We now go to the building and measure the distances $P\,E$ and $P\,D$. They were 21.521 and 65.719 feet respectively.

4. Let us put R for the unknown distance $P\,C$, m for $P\,E$ and n for $P\,D$. We then have $tan x = m/R$, and $tan\,2x = n/R$. Placing these values in the formula $tan\,2x = 2\,tan x/(1\text{-}tan^2 x)$, we get after reduction $R = m\sqrt{[n/(n-2m)]} = 36.64$ feet = distance of camera from wall.

5. Prudence suggested taking angles and distances to the left of P also. The length $p\,a$ between the images of P and the south end of the wing on the picture was 3.788 inches and its half $p\,b$ and $b\,a$ 1.894 inches. On the wall these were $P\,A = 18.463$ and $P\,B = 8.835$ feet. Calling the equal angles y and proceeding as before, R turned out to be 42.63 feet. As this y value was six feet longer than the x value, great consternation prevailed for a while. When no mistake whatever could be found in the principle, the measurements and the computation, the error was judged to be due to the erroneous location of P on the photograph.

6. The point P was therefore shifted on the picture one-tenth of an inch to the left. This called for entirely new measurements on the photograph and on the wall, as well as a new computation. The second approximation then made R equal to 37.35

and 40.26 feet, with a difference of only about half of its former value.

7. The point P was accordingly shifted on the picture another tenth of an inch to the left. The new measurements then made $p\,d=8.732$, $p\,e=4.366$, $p\,a=3.588$, $p\,b=1.794$, inches, $PD=66.655$, $PE=22.102$, $PA=17.527$, $PB=8.342$ feet, and R was found to be equal to 38.08 and 38.04 feet. The mean, 38.06 feet, was then accepted as the true distance of the camera from the wall.

8. Then the angles $x=30°8'$ and $y=12°22'$ were easily found. Knowing that $abped=2x+2y=85°0'=12.320$ inches on the picture, we have $1°=0.145$ inch. As a radian is 57.°3, the focal length of the camera was $57.3\times0.145=8.30$ inches. The total length of the film was 32.8 inches or 226 degrees.

9. To determine the height of the camera, we stretch a fine thread over the photograph and try to find a row of bricks or stones or a mortar line that is perfectly straight not only across all projections and recesses in the wall, but also across all buildings whatever. This was then in the same horizontal plane with the camera. The oversight made in not determining this line before locating the point P is, of course, mainly responsible for the erroneous values of R obtained at the start. The surest safeguard against such errors, especially in the case in which the thread method cannot be employed, is to measure both to the right and to the left of P.

10. When a cycloramic photograph is bent into a cylinder *abped* with a radius $C\,a$ equal to the focal length of the camera, and the eye placed in its axis c and in the plane of the horizontal line, the view is identically the same as one would see if he stood in the same spot that the camera occupied and looked at the real objects. The sinusoidal or bulging appearance that a near building presents in the plane picture, together with the alignment of all the buildings as if they all faced the same point of the compass, then disappear completely in the cylindrical one, and the photograph is as true to its original as any mathematical critic could desire.

SALT IN 1921.

The United States Geological Survey reports that the production of salt in the United States in 1921 was 4,981,154 tons, valued at $24,557,966, a decrease of twenty-seven per cent in quantity and eighteen per cent in value as compared with 1920.

THE MUSEUM, THE ORIGINAL EXPONENT OF VISUAL EDUCATION[1]

By Frank C. Baker.
University of Illinois.

We hear a great deal in these days about the value of visual education, and a society has been organized for the promotion of this method of teaching. This is indeed one of Nature's most effective methods of teaching her children the laws of the universe. It is said that we acquire much more information through the eye than through any other sense organ of the body. One often hears the expression "seein' is believin," which expresses this truth in a homely way.

The museums of science and art have been for many years pioneers in the field of visual education, bringing to the public, more or less imperfectly in the earlier years, the facts of Science and the beauties of Art. The museum is often called the "people's university," and it is quite true that the great majority of the population of our large cities acquire their only knowledge of the great world about them by visits to the museums, art galleries, and zoological gardens, where the fowls of the air, the beasts of the field, and the fishes of the sea, past and present, are gathered together in such an assemblage as Noah never dreamed of in his day and generation.

The value of the museum as an efficient aid in educational work is fully realized by but few educators. Even in many of the large cities there is little real cooperation between the local museum and the educational system, and this is by no means entirely the fault of the museum administrators. Visual education seems to center about pictures, lantern slides and moving pictures, and the aid that may be rendered by the museum exhibits is, in the main, unthought of. Perhaps many of our museums are to be held responsible for this condition, their exhibits being so often entirely useless to the teacher because of faulty installation, of value to the systematic student, but valueless to the general teacher. The cooperative association of school and museum in New York, Chicago, Milwaukee, and some other cities, augurs well for the future of the museum in finding its true place in the educational system of the present age.

In a recent article on the "Contribution of Museums to Public School education," Mr. Peter A. Mortenson, Superintendent of Public Schools of Chicago, says: "The value of

[1]Contribution from the Museum of Natural History, University of Ill., No. 25.

museum material as a factor in reinforcing school instruction has, no doubt, been recognized generally enough, but the difficulty lying in the way of its wider utilization has been the failure to find the museum material so organized that it would appeal to the dynamic interests of the children and at the same time portray the life that it was collected to represent." The larger museums, and even some of the smaller museums presided over by far-sighted curators, are removing this unfavorable criticism, and are preparing some of their exhibits to meet the requirements of the teacher of the grade school.

That the museum is also of value in reinforcing instruction in the universities and other higher institutions of learning seems equally certain, supplementing by the exhibits the material used in the classroom and laboratory, the larger value being in the coordination of all the material which may have been seen in the classroom only as isolated parts of the whole subject. This value of museum material has been recognized for many years and almost every college and university has its museum, even though it be a small one. Of late years some of the universities have drifted away from the use of the museum, hence the unsatisfactory condition of much of the material in many university collections and the general poor opinion of most of such collections among museum men. I wish to indicate, briefly, some of the ways in which the museum may be useful in supplementing the general courses given in a university.

The modern teaching of geography consists not so much of political boundary lines, as of people, industries, natural reresources, and physical features. And here the museum can be of the greatest help in visualizing the text book. The cultures of people, how they utilize their natural resources and acquire material not found in their own country; the physical character of the country which has governed the development of the people—mountains, streams, valleys, deserts—all of these and more may be visualized in such a manner that the student easily grasps the significance of the facts of climate, topography, or geographic position, which have been potent in shaping the destiny of a group of peoples. The industries of certain countries may be shown, such as the common articles upon which we depend for our daily comfort— cotton and its derivities, iron and steel, pearl and ivory buttons, coal, aluminum, and many others. Exhibits showing the processes of manufacture from the collecting of the raw material to the selling of the finished

product, with all of the by-products indicated, are of potent value to the teacher of geography.

And in the natural sciences—geology, zoology, botany—the museum is indispensable because it visualizes the courses given in the different branches. The student pursuing a course in systematic zoology may study the synoptic collection, arranged so that the major groups are exhibited to show their development from simple to complex organisms, their relation to each other and to the past history of the earth, the extinct groups being shown with the recent groups. Such an exhibit links together all life, showing it to be interrelated on every hand.

The student of geology may crystalize his course in historical geology or paleontology by consulting the exhibits of fossils, in which he may follow the changes of life from its first definite appearance in the early Cambrian seas to the latest prehistoric period. Here can be shown as nowhere else, the dying out of one type of life and the advent, almost instantaneously as it seems, of another. Such examples as the dying out of the Ammonites in the Cretaceous, the rise and fall of the huge saurians in Mesozoic times, and the advent of the mammals in Coenozoic times indicate the usefulness of such exhibits. The subject of coal can also be made more understandable by an exhibit of the peculiar flora of the Carboniferous. The evolution or descent of an animal and its modification during descent can be shown most effectively by groups arranged with specimens or restorations, supplemented by illustrations, so that the student grasps almost instinctively the significance of the subject. Such lines of descent as the horse, sloth, elephant, and armadillo can be very effectively shown.

Physiography naturally lends itself to the museum treatment and all phases of earth processes may be illustrated most effectively. The work of ice, snow, water, the sea, vulcanism, erosion, these and other subjects may be made clear by the use of properly constructed models of effective sizes.

The modern group idea has revolutionized museum exhibits. By this medium we are able to visualize the whole realm of nature, history and art. No longer must animals be seen only on shelves arranged in rows, like canned goods in a grocery; they may now be seen in their natural environment, in occupations such as they perform when unmolested by their arch-enemy, Man, the elaborateness and breadth of vision being limited only by the pocket book of the museum. In one museum may be

seen the bird life of an island in the distant Pacific; in another, one may hunt the mountain sheep or the grizzly bear in the great mountains of the west; or visit a bird rookery in Florida or the islands of the West Indies. The fast disappearing native races of this and other continents may return and perform their ancient tribal ceremonies in the groups of the museum, which often appear so lifelike that one almost expects the wax effigy to breathe or to throw an upraised spear or stone through the glass of the case.

These groups need not be large or expensive. One of the most effective habitat groups in the museum of the University of Illinois is in a case 5x6x2 feet in which is shown an old decaying log with its characteristic animal life in the midst of a local environment, a small patch of almost virgin woodland near the university. An enlarged photographic background tinted, makes the old log appear to be in the woods, while spring flowers, birds, toads, and butterflies add to the naturalness of the exhibit. This group, including case and all accessories cost but $400.

The modern study of natural history, now called ecology, may be very materially aided by these museum groups which visualize the life of different kinds of animal habitats, the natural homes of different species. Thus we may see the polar bear and musk ox of the Arctic, the deer and elk of temperate climes, and the gaudy birds of the tropics, all examples of the effect of climate on animal life. Pond life may be distinguished from river life, prairie life from forest life, all these may be shown in a museum group, surpassed only by the living animal in its real home. Often, two or more habitats may be shown in the same group for comparison, as a swampy, quiet pond behind a beach barrier, the animals of the quiet pond being strongly contrasted with the animals of the rougher water habitat of an exposed lake shore.

In the teaching of economic entomology, the museum is again a valuable aid. In small groups, insects injurious to certain plants may be shown in their natural habitat on the plant as they would be seen when at work doing the injury, and the transformations may be shown so that the farmer or student may recognize the stage when the insect is most injurious. Such subjects as corn insects, grain insects, insects of the apple, pear, grape, garden insects, and many others may be shown as when living. These exhibits are far superior to the ancient custom of pinning the specimens in a glass covered tray, for the psychology of the group idea makes the insects seem more real.

And in botany, exhibits are possible that will be an aid in the teaching of some branch of the subject. Forestry, extinct plants, evolution and descent of certain types, these and other subjects may be treated in museum exhibits.

These examples might be amplified indefinitely, but enough have been given to show that the museum is a potent agency in modern education, a fact that is, perhaps, not fully realized by educators in general. The museum is too often thought of as a storeroom or mausoleum in which musty specimens are stored away to be pored over by spectacled savants who live in a world by themselves. It is sadly true that this conception is not without foundation, for there are many museums in universities, colleges, normal schools, and academies, which are this and nothing else. But the modern museum is a vastly different thing, filled with objects potentially arranged, awaiting use by all progressive teachers.

In closing, may I use the words of one of England's greatest museum men, Sir William H. Flower, who says, "It is not the objects placed in a museum that constitute its value, so much as the method in which they are displayed and the use made of them for the purpose of instruction."

[1]Read before the Biology section of the Illinois State Academy of Science at Rockford, April 28, 1922.

GETTING NEW STUFF ACROSS.

By Henry Flury,

Eastern High School, Washington, D. C.

This is a slangy title which I have purposely chosen because it has a "straight from the shoulder" or businesslike ring to it. I see in my mind a clear picture of an earnest, clean-shaven man behind a long table, leaning over face to face with a customer, making a sale. He is "putting the deal across." That is what every good science teacher ought to be doing—"selling" science to his pupils.

The methods of the salesman have something to commend them to the teacher. The salesman does not haul a load of merchandise up in front of his customer and then dump it there and ask for a bid. No, what he does first is to "create a desire" on the part of the prospective customer for the thing he is selling. Applying this to the teacher, he has one of the "best sellers" on the market if he knows how to put it across. How can this be done?

From the stone age down, the mind of man has ever been speculative, people love to theorize, and biographical studies reveal that the so-called "genius" has been the person who was able to dream great dreams and *harness* those dreams to material expressions. I remember seeing a beautiful oil painting called "Reunion," in which an entrancingly rapturous woman is swept up into the ether in the arms of an angel of the opposite sex. It represented to me a union of matter and spirit. In our high school work if we can capture this theorizing tendency and harness it to every day life without getting too far afield, we have a powerful lever of successful instruction. Some of the newer discoveries and the theories following in their wake afford a fruitful field for the intellectual harvest. However, let us have due regard as to what the place of theory is with reference to fact.

Theories come and theories go and "the path of scientific progress is strewn with beliefs which have been abandoned for lack of evidence, as burst shells strew a battlefield, and it is our boast that they are *abandoned,* and *not lugged along* the line of march."[1] But they do serve a useful purpose in giving us a synthetic view of the universe. Science teaching in the past has emphasized the analytic mood which was eminently proper in an age that accepted superstition equally with fact but the time has now come for getting ourselves together. The specialist will run us into a hole with his analyses if we don't correlate his findings with those of others. Slosson has shown us this aspect in his *Creative Chemistry.*[2] Bergson, one of the greatest philosophers of modern times, deals with it in *Creative Evolution.*[3] The trend of thought today, after the war, is constructive; we are on the threshold of a new age of human progress and the human mind and soul thrills with the wonderful possibilities.[4] Surely, the science teacher has "something to sell."

The unity of the different sciences must be shown; they are not discrete but interdependent. Chemistry must be defined as the science of matter and energy with emphasis on the nature and constitution of the matter; physics must be defined as the science of matter and energy with emphasis on the forms of energy, its measurement and transformations; biology must be defined as the science that deals with life and that embraces the laws of chemistry and physics, though not necessarily limited solely to

[1]*The Foundations of Zoology,* Wm. K. Brooks, Macmillan.
[2]*Creative Chemistry,* Edwin E. Slosson.
[3]*Creative Evolution,* Henri Bergson.
[4]*System of Animate Nature* (2 vols.), J. Arthur Thompson, Henry Holt, 1920.

them, because the cell has apparently an originative or selective power of its own. Geology comes in to explain the strata and reveal the fossils that supply missing links in the chains of plant and animal evolutions. Chemistry comes to the aid of geology and vice versa. They dovetail, they interpenetrate; it is only our *purpose* or our method of study (analysis) which separates them. They are a unity. If we can get visions of the symphony, if we can get the master formulae that makes nature a harmonic and rational system, we are getting somewhere. The stoker down in the hold of the ship doesn't know where he is or where he is going. The captain on the bridge, however, has a broad and comprehensive outlook and is able to steer a sensible course. Let us be captains and be able to give our pupils some of these larger and more comprehensive conceptions of what the whole "fuss" of education is about. Then I am sure they will make better citizens as well as better college-fodder.

There is a great deal of talk now about radio telegraphy and telephony; it is in the daily papers and magazines; there is much wise palavering about "wave-lengths", vacuum tubes and the ether. Here is a good chance for the science teacher to utilize these popular words to elaborate on the ideas (and, perhaps, just as important, lack of ideas) of the "ether" and extend them to the other forms of energy.

While we are speaking of the much discussed ether it might be well to listen to what that electrical wizard, Dr. Charles P. Steinmetz, has to say[5] when he denies the existence of a substance that is not a substance, of something that is a solid of high rigidity while at the same moment it has the tenuity or rarity so that all heavenly bodies whirl through it without the least friction. Such a contradiction must be abandoned, he argues. Is the ether, then to be one of the "beliefs which strew the path of scientific progress which has been abandoned for lack of evidence" as Brooks suggests?

We have organized a radio club in the student body and have installed a two stage amplifier triode set with good results. Interest is created all along the line when they experience and handle those objects which involve quite a little theory.

The close relation between heat waves, light waves, electric waves and magnetic waves should be shown. The fact of periodic vibration, of the commonness of simple harmonic motion, of rhythm, of harmony and beauty can be brought out.

The wonders of the spectroscope, the romance of helium being

[5]*Popular Radio*, p. 161, July, 1922.

discovered on the sun many years before it was found on the earth, lend themselves to this treatment.

Radioactivity, the problem of the sun's heat, the sun as a source of energy—these present a fruitful field for speculation.

The importance of temperature and pressure, the manufacture of liquid air, the isolation of the rare gases, the service of mathematics in the infinite series and how the series were applied to electro-dynamics shows the interrelation of science and mathematics.

The fineness of precision of modern instruments, the contributions of astronomy—these afford the basis for stimulating mental activity.

These larger and newer conceptions when properly developed will create a taste for science—and that is the most that a high school course can do. A course in high school English does not make writers of the students; a course in science does not make scientists of them, and getting the new stuff across does help to give them a more intelligent understanding of the world in which they live.

PRODUCTION OF ALUMINUM IN 1921.

The value of the aluminum produced in the United States in 1921 was $10,906,000, as compared with $41,375,000 in 1920, according to the United States Geological Survey, Department of the Interior. This great decrease was due not only to a decrease in the price of the metal but to the large curtailment of its use in the automotive industries. The price quoted was steady at 28 cents a pound from January until the middle of July, when it was cut to 24.5 and to 25 cents, remaining so until the first of December, when it was cut to 20 cents. Imported aluminum could be bought throughout the year at 2 to 3 cents below the prices quoted for domestic metal of the same grade.

The imports of semi-manufactured aluminum in 1921 were 32,665,300 pounds, as compared with 39,298,650 pounds in 1920. The exports of aluminum in 1921 were 2,196,100 pounds, as compared with 9,407,650 pounds in 1920.

PROFESSOR JOHN M. COULTER, OF CHICAGO, A TRUSTEE OF THE THOMPSON INSTITUTE FOR PLANT RESEARCH.

Chicago, June 00.—The board of trustees of the Thompson Institute for Plant Research at Yonkers, New York, includes two botanists as scientific advisers, one of them being Professor John Merle Coulter, Head of the Department of Botany at the University of Chicago. The director of the Institute is Dr. William Crocker, formerly of ths university faculty, who received his Doctor's degree at Chicago in 1906.

The Institute, which was established by William Boyce Thompson, of New York City, is to investigate the fundamental problems connected with plants, some of which will have a practical application to plant production. The laboratories have been planned and are in course of construction.

THE HIGH SCHOOL-COLLEGE PROBLEM.[1]

By Marie Gugle,

Assistant Superintendent of Schools, Columbus, Ohio.

Briefly stated the high school-college problem is how to secure a better coördination between the mathematics of the secondary and higher schools; or how to make the two articulate better. It involves educational aims, selection of subject matter and textbooks, teaching methods more particularly, and a constant study of the needs and abilities of the pupils, as does any other problem of instruction.

This problem and similar ones have been studied and discussed at meetings of high school teachers time after time. Occasionally some college professor has been asked to address the school group. Too often he has failed to use his opportunity in a constructive way and succeeded only in discouraging the teacher by saying, "If you would only teach the pupil to solve a quadratic or to add fractions, etc." The teacher knew that when the pupil was in his class, he understood quadratics and by Rugg tests he had developed a standardized skill at the time. Unfortunately, a year or more elapsed between that time and his appearance in the college class. The teacher continued at a loss to know how his instruction could carry over.

Now that the college teachers are concerning themselves about the problem to the extent that they invite secondary teachers to come to their meetings and give a share of their program to its discussion, perhaps a better solution will be forthcoming—not because any one person has the magic formula but because such a method means seeing the problem from each other's point of view.

For too long a time each group of teachers has cried aloud against the one preceding about lack of preparation. The cry began with the college professors and ran down the line through the senior high school, the junior high, the elementary, and the kindergarten. In desperation the last group exclaimed, "How can you expect me to do anything with these children when they haven't any brains? You must blame it on the parents." What a vicious circle, for now we are back again to the college professor as belonging to the group of parents.

Then there is another way we could blame it on the college professor if we so desired; for, does he not train the ones who go into the high schools to do the teaching? If they fail in their

[1]Read before the Ohio section of the Mathematical Association of America, April 14, 1922.

instruction, must not the professor who trained them share the blame?

To fix the blame is far from our purpose, however. Instead we plead for a more careful scrutiny of the materials and methods used by each group and an open-minded attitude on the part of each in order that through a better understanding the work of both may be improved.

For many decades the subject matter included in our courses of study was determined wholly by college entrance requirements, based too, on those phases of the work which could be tested in an examination. Naturally the secondary algebra became an uninteresting drill on more or less meaningless processes. The high school algebra instructor said to the elementary teacher, "Drill on the fundamentals of arithmetic, especially fractions. I'll teach the algebra myself."

But the drill in fractions in arithmetic came mostly in the fifth and sixth grades. In the seventh and eighth grades, the pupil was lost in the mazes of partial payments, stocks and bonds, present worth, and other phases of advanced business arithmetic which the pupil could in no wise master for he lacked the necessary background of experience. During these two years he lost part of his skill in the fundamental processes and fractions through lack of use. So there was a gap between his elementary arithmetic and his algebra in the ninth grade. Therefore, his algebra teacher, very wise in his own conceit, bitterly criticized the elementary teacher and said to the pupil, "You can't do a thing. You can't even add and you don't know a fraction when you see one."

As a matter of fact, the algebra teacher did not present his subject as an enlargement of arithmetic but as an isolated new branch which few pupils could recognize as even related to any previous work in mathematics. If this teacher had planned just a brief review of the necessary arithmetic process as an apperceptive basis for the related algebraic work, he would have found that the pupil could readily recall the arithmetic process and through it could acquire the algebraic one much more rapidly. He made his mistake in method because he considered himself a teacher of algebra instead of a teacher of mathematics.

During the seventh and eighth grades, a far greater wrong was done to the pupil than that resulting in his loss of skill, for with a few weeks of practice that could be regained. By forcing him to conjure with problems he could not understand, he

developed a habit of juggling with figures—anyway to get the answer. Oftentimes he developed a dislike for mathematics, "because he couldn't see any sense in it." But worst of all, he lost his faith in his own ability.

As a result of the struggle through these grades seven, eight, and nine, many grew discouraged and dropped out of school, or at least dropped the study of mathematics. The subject got a very bad reputation that is exceedingly hard to live down.

A few of the braver pupils continued the work in geometry. This was such an entirely new and different phase of mathematics that the pupil felt he no longer needed arithmetic nor algebra. He did not use them, so he proceeded to forget what he did know. He began memorizing a lot of things called theorems and again he knew little of "what it was all about." Suddenly in the latter part of the tenth year he met a problem he could not solve for he needed the forgotten algebra. It had a quadratic equation in it. The geometry teacher criticized the algebra teacher for failing to teach the one most needed process. He made the pupil feel utterly discouraged. Who was most to blame? Surely the geometry teacher failed to realize his opportunity. Just a brief review of the quadratic would have sufficed to bridge this, another gap of almost a year. A year does not seem so long to grown-ups, but we should remember that in this grade it is one-tenth of the pupil's school life. Can you recall how long it seemed to you when you were a little fellow from one Christmas to another?

Plane geometry in the tenth grade ended the mathematics for a large majority of pupils. A few elected solid geometry in the eleventh year. Some of the survivors took a third semester of algebra the latter half of the year. There was, consequently, a gap of a year and a half between Algebra II and Algebra III, with more denunciation on the part of the teacher because he had to spend all his time reviewing ninth grade algebra and had so little time left for the more advanced work.

All of the larger high schools offer a semester of plane trigonometry and many offer a fourth semester of algebra; and yet, when these pupils come to college many of them fail. The number entering college at all is only a small percent of the number in school in the seventh grade. Is this to be the measure of our success? If so, has our teaching been worth the tremendous cost the public has paid for it? A more enlightened public is demanding better returns on its investment. We must find a way or make way for others who can.

Much has already been accomplished through the National Education Association, through associations of mathematics teachers, and through individual experimenters. The biggest contributions, however, are the work of the National Committee on Mathematical Requirements and the extension of the junior high school.

The first point of attack was the work done in the seventh, eighth, and ninth grades. The National Committee rightly maintains that if we plan the work for these grades, which best suits the needs and abilities of the pupils, regardless of whether they continue in further study or not, we shall have given the very best preparation possible for those who do continue. Therefore, they recommend a unified course in elementary mathematics for these three grades. This general mathematics includes business arithmetic, simple accounts, intuitive geometry, elementary algebra, somewhat simpler than the former first year algebra but with several more valuable additions, a little numerical trigometry, and a g'impse into demonstrative geometry.

Some of the old type teachers of higher work fear that such a course gives a smattering of mathematics. To such a one I can only say, "Come and see."

Dr. Kilpatrick says, "As teachers we fail, if at any time, our children are not disposed and equipped to go on." General mathematics stands this test far better than the old upper grade arithmetic and ninth grade algebra. The pupils are more disposed to go on and are better equipped to do so. Such a course bridges that first big gap, for the various parts of arithmetic, geometry, and algebra are so interwoven that the skill has no chance to lapse. Its greatest value, however, lies in the fact that it fosters the child's enthusiasm and interest and gives him a sense of mastery and achievement. Mathematics is no longer the bugbear it used to be. He sees in it something worthwhile and takes joy in his success. It makes him more eager to attack the tenth grade work in a frame of mind more propitious and necessary to success.

The organization of the junior high school mathematics has progressed far more than that of the senior high school. Since the extent of geometric lore learned intuitively in the junior high school makes the transition to demonstrative geometry very easy, in the tenth grade the pupil is already familiar with its terms, relations, and symbols, so that only the logic of the dem-

onstration is new. The National Committee has made several recommendations for reorganization of the work in grades ten to twelve. Among these are that the year and a half usually given to plane and solid geometry be reduced to one year or less; that some of the theorems previously developed intuitively be taken as assumptions. It suggests a list of fundamental theorems.

It further recommends certain definite topics in the usual courses in Algebra III, plane trigonometry, and statistics, and for the larger schools a course in the beginning of calculus. These recommendations are in accord with the best European practice.

The report says, "At the present time, the topics suggested can probably in the majority of high schools be given most advantageously as separate units of a three year program. However, the National Committee is of the opinion the methods of organization are being experimentally perfected whereby teachers will be enabled to present much of this material more effectively in combined courses, unified by one or more central ideas such as functionality, graphic representation, etc."

It offers four plans or orders without stating preferences.

Plan A

Tenth year: Plane demonstrative geometry, Algebra.
Eleventh year: Statistics, Trigonometry, Solid Geometry.
Twelfth year: Calculus, other elective.

Plan B

Tenth year: Plane demonstrative geometry, Solid geometry.
Eleventh year: Algebra, Trigonometry, Statistics.
Twelfth year: Calculus, other elective.

Plan C

Tenth year: Plane demonstrative geometry, Trigonometry.
Eleventh year: Solid geometry, Algebra, Statistics.
Twelfth year: Calculus, other elective.

Plan D

Tenth year: Algebra, Statistics, Trigonometry.
Eleventh year: Plane and solid geometry.
Twelfth year: Calculus, other elective.

No doubt the committee is correct in saying that for the present these subjects in the senior high school should be taught separately. They must be, except in a few experimental schools, until some one organizes them into a unified or general course and publishes it as a text. Tandem courses in algebra and geometry have been tried and found wanting.

In the general course for junior high schools the intuitive

geometry fuses beautifully with arithmetic and algebra and forms an excellent medium through which to present the algebra. But the demonstrative geometry, as such, is logic rather than mathematics. Therefore, it seems impossible to include it in a truly unified course for the senior high schools. This fact may mean that a one-year course of plane and solid geometry should be kept as a separate unit. It seems highly desirable, however, to combine into one general course the other parts of senior high school mathematics, namely, the so-called Algebra III, trigonometry, and the elements of calculus and analytics.

In the junior high school the graph is used continuously to illustrate other mathematics. The pupils become rather adept at making graphs and interpreting them. In the ninth grade they also study graphically the various types of equations, including the straight line, hyperbola, parabola, circle, and ellipse. If the senior high school could follow with an enlarged general course, the big gaps would be tightly closed; the pupils entering college would have a far better working knowledge of the subject.

Thus far, it has been assumed that pupils elect all possible secondary courses in mathematics. Unfortunately, many try to enter college with only one or two units in the subject. Whether or not the recent ruling of the Ohio State Department of Public Instruction will make it necessary for the university to accept candidates with no mathematics training or not, I can not foretell. In our public schools, we still have all three years of junior high school mathematics listed as required. For many years all senior high school mathematics has been elective. Besides in rare cases where an otherwise capable pupil could not master ninth grade mathematics, the principal or superintendent exercised his discretion and permitted such a pupil to substitute another subject. Since the new ruling of the State Department went into effect, no request to drop ninth grade mathematics has been brought to the superintendent's office.

In the tenth grade most of the pupils who will go to college elect mathematics. If, however, as is the case with many arts college candidates, no more mathematics is elected, there is a gap of two years in which most of the previous work is forgotten. How to make the high school and arts college work articulate in such a case is truly a problem. Of course, one solution would be to make arts mathematics optional and for those that do take it

require more preparatory work. Through high school vice-principals or other faculty advisors, pupils who know they will take mathematics in college can be shown the need of electing the necessary secondary courses. The greatest difficulty comes with those pupils who do not know what they want to do. For such, perhaps, a preparatory course in college without credit could be planned. Two years of high school mathematics can never be sufficient preparation for college mathematics even in the Arts College.

A fair minimum requirement for arts mathematics would be, besides the junior high school course, a year of geometry (preferably plane and solid combined) and a semester of algebra (algebra III). If arts candidates would elect this algebra in the senior year, the articulation would be better.

If the colleges insist on requiring mathematics of all arts freshmen, it must mean a lowering of their standard of work, for this college has many capable students of decided literary tendencies who have neither interest nor ability in mathematics. For these another option should be possible.

Candidates for engineering colleges usually have their plans laid in plenty of time to get the necessary preparatory work. These pupils should be strongly advised to take all the mathematics offered in the high school; A fair minimum requirement for engineering candidates would be, besides the junior high school mathematics, a year of geometry (preferably plane and solid combined), a semester of algebra (Algebra III), and one of trigonometry. Until the senior high schools reorganize their courses, they will continue to devote a year and a half to geometry. This minimum course, unfortunately leaves a year or at least a semester with no mathematics. To obviate this difficulty, Columbus offers a fourth semester of algebra. Instead of this, it might be better to give a general review of high school mathematics including the essentials of algebra, geometry, and trigonometry. Such a course would need careful outlining and handling by a skillful teacher for there is no text suitable. Planning such a course would be a suitable project in which high school and college teachers could cooperate.

The problem of the gap between secondary and college mathematics will be solved more satisfactorily when a general course is organized for the eleventh and twelfth grades, including the essentials of algebra and trigonometry, with the elements of calculus and analytics. It should be understood that in the

calculus suggested is meant only the kind and amount recommended by the National Committee.

Surely such preparatory training should be satisfactory if the pupil has maintained a reasonable standard of work. What is a reasonable standard? How is it to be determined? We can readily agree that 70 or 75 per cent would be reasonable, provided we could be sure that it meant that the pupil had mastered seven-tenths or three-fourths of all the work covered. We all realize the unreliability of school grades or ratings, yet some teachers have failed pupils on 69 per cent. How to standardize our ratings is a problem for the psychologists to solve. However, we must always expect to have a rather wide range of abilities among graduates of the same high school. A still wider range must occur among the college freshmen who come from scores of different schools. Is it not necessary, therefore, that the colleges adopt some plan of securing a semblance of homogeneity out of this heterogeneous group. To do this some colleges have tried a review course of several weeks, followed by a test. Pupils failing the test are compelled to review high school algebra. The weakness of this plan is the false assumption that any set of eight or ten questions can be formulated, which alone can determine a pupil's ability. It comes before he has adjusted himself to the greatest change of environment he has ever made.

Perhaps a fairer plan would be to classify the freshmen partly by mental tests, now usually given to all freshmen, and partly by the quality of work done in high school. A pupil who has consistently maintained excellent grades in high school and has a satisfactory I. Q., will in all probability do good work in college. He may require several weeks to make adjustments, but he will soon find himself and make good. On the other hand a pupil who has struggled through high school on fair or barely passing grades and has an average I. Q. or less, should be grouped with others of like ability and be given a less intensive course. I do not believe that such a group should be made to repeat secondary algebra as such. But the teacher should be willing to review a secondary topic whenever necessary. To this group, the strongest teachers shou'd be assigned. With proper teaching and sympathetic guidance, a large number of these students will succeed. Many of these pupils are worth saving, for we must not forget that many of the most successful engineers and other men of affairs made only fair grades in college classes.

Much has been suggested about reorganizing secondary school courses. Not all such work should be done there; much could be done with profit in reorganizing freshmen mathematics both in selection and arrangement of materials and in methods of presentation.

This year the Ohio State University is experimenting with a new text in general or unified mathematics. Previously it used a college algebra, a trigonometry, and an analytics. On request I read all of these texts, for I was asked to discuss them.

No doubt, the algebra is better than many of its competitors. The authors make this statement in their preface:

"The application of algebra in the more advanced courses in mathematics has been an important factor in determining the subject matter. Not only are some of the topics usually treated in the traditional course in algebra entirely omitted, but in each chapter the material is restricted to the development of those central points which experience has shown so essential." The student has not had this experience, so he cannot see why all these abstract processes are so essential. Fully three-fourths of the exercises in the text are pure, abstract mechanical manipulations. Its presentation of all topics is general or deductive. Such generalizations are all right for those topics previously presented inductively in secondary mathematics. But it is just as necessary that topics entirely new to freshmen be presented by this method as it is for the high school senior. As examples, logarithms and determinants may be cited. In its chapter on graphs, the subject is presented as though entirely new, but not nearly so well as in the analytics text. The approach is still better in the unified text. When one thinks how simply the graph can be presented to junior high school students and how eagerly they take it, one is thankful that the college presentation is not their first introduction.

Many of these texts use Greek letters without even naming them or giving their significance. The analytics is the only text that even names them. It merely lists the alphabet.

The trigonometry is taught on the assumption that the pupil has had no previous work in the subject. The text starts out thus on the subject:

CHAPTER I.

Angles.

"Let OX be a fixed straight line and let a straight line OP, initially coincident with OX, turn about point O in one plane;

then, as it turns, it is said to describe the angle XOP. The magnitude of the angle depends on the amount of revolution which OP has undergone. OX is called the *initial line.*

"In Trigonometry there is no limit to the magnitude of the angles considered."

How much of a vision of the subject of trigonometry can such an introduction give? How much interest is thus aroused? Then on page 7, all the functions are named at once.

The particular text submitted is an English publication, but its use of the English language is not always correct; e. g., note the clumsy order and resultant lack of clearness in the following: "The angle subtended by a side of a regular figure at the center of its inscribed circle is 36°. How many sides has the figure?" And, "A Radian is the angle subtended at the center of a circle by an ARC equal in length to the Radius."

This text also adds confusion by using the English decimal point, a dot placed considerably above the line of writing. In the preface, the authors themselves have voiced the usual criticism to be made against authors of trigonometries.

"During the last few years a great change has come over the teaching of Elementary Mathematics. The laborious months hitherto spent in acquiring skill in the manipulation of Algebraic and Trigonometrical transformations have often given the beginner a dislike for Mathematics and have retarded his progress."

"It has been shown that it is quite possible to arrange (for the average student) a course of Mathematics which is both interesting and educational, by constantly keeping before him the practical application of the subject, and omitting as much as possible those parts of Mathematics which are purely academical. The object of this book is to give the reader such a working knowledge of Elementary Trigonometry, without avoiding the difficulties or sacrificing thoroughness. Much that has hitherto been found in the textbooks has been omitted, and the examples throughout will be seen to be more practical than is usually the case."

They yield to the pressure of tradition, however, in their last paragraph, which says, "To meet the wishes of many teachers who use this book we have added an appendix containing a considerable number of Identities."

Again we are thankful that trigonometry has been introduced to ninth grade pupils and continued, we trust, in the senior high school.

The text in general mathematics submitted has a much saner teaching method. Its introductory paragraph is headed, "What is it all about?" Its plan is best described in its preface.

"Under the traditional plan of studying trigonometry, college algebra, analytic geometry, and calculus separately, a student can form no conception of the character and possibilities of modern mathematics, nor of the relations of its several branches as parts of a unified whole, until he has taken several successive courses. Nor can he, early enough, get the elementary working knowledge of mathematical analysis, including integral calculus, which is rapidly becoming indispensable for students of the natural and social sciences. Moreover, he must deal with complicated technique in each introductory course; and must study many topics apart from their uses in other subjects, thus missing their full significance and gaining little facility in drawing upon one subject for help in another."

"To avoid these disadvantages of the separate-subject plan the unified course presented here has been evolved. This enables even those students who can take only one semester's work to get some idea of differential and integral calculus, trigonometry, and logarithms. And specialist students, as experience has shown acquire an excellent command of mathematical tools by first getting a bird's-eye view of the field, and then proceeding to perfect their technique."

Later, he adds, "Care has been taken to make the concepts tangible, relate them to familiar ideas of daily life, exhibit practical applications, and develop the attitude of investigation."

The author has eminently succeeded in living up to his preface far more than is usual. His consideration for the pupil has not been at the sacrifice of good mathematics. The text covers a great many topics, almost too many if all are entirely new. Fortunately the reorganized plan of preparatory mathematics gives a good introduction to a great many of these such as the graph, trigonometric functions, and logarithms. With such a foundation and such a text for freshmen a better articulation between high school and college work should result.

In the public schools we have found it possible to plan good courses of study, to put into pupil's hands satisfactory textbooks, and yet not get the desired results unless we also put a competent teacher in charge. There is a wide range of variation in teaching ability, almost as much as in pupil ability. Fortunately, the public schools are striving to make teaching a real profession. To that end we no longer assume that a mere college graduate is

competent to teach in high school. The state law requires a definite amount of professional training before teaching. School systems have developed plans for supervision in the teaching. More and more stress is being laid on training teachers in service. No less a mathematician than David Eugene Smith once said that the poorest teaching done anywhere from the kindergarten to the postgraduate school is done in the freshman year in college.

There are several reasons for this condition. The elementary teacher feels that more prestige comes from teaching the sixth grade than the first; the junior high school teacher feels the same way about the ninth grade as compared with the seventh; and the senior high teacher, about the twelfth and tenth grades. So the stronger and more experienced teachers tend to the higher classes of his school. For somewhat similar reasons, the heads of departments in colleges will choose junior and senior classes, but it is the freshmen who most need his skill.

The state law has no jurisdiction over professional requirements for college teaching. It might be embarrassing to inquire how many college professors have had training in teaching or experience in teaching under supervision before attempting to teach in college. Too often some young student working on his master's degree, who made a good record as an undergraduate, is made an instructor, and soon promoted to an assistant. Given much natural ability and fair energy after experimenting for several years on freshmen, he sometimes becomes a very successful professor. But think of the poor freshmen while he was learning his art of teaching.

Embarrassing financial conditions in some colleges have made it impossible to provide a sufficient number of teachers of the highest type, especially during the recent unprecedented growth of college enrollments. But college authorities have not yet realized that even a young Ph. D., without training or experience in teaching, is not a suitable person to put in charge of freshmen classes. If he must be used, put him in charge of seniors where he will do less harm, and give freshmen to the capable experienced professors. Public school people put this principal into practice by putting only teachers of proved ability and successful experience in charge of the first grades. Our beginning teachers, after careful training for teaching, are usually placed in the third and fourth grades. The freshmen are college first-graders. In both first grades we particularly need the artist

teachers. If you must use these young instructors, insist that they take training in your own schools of education and during their apprenticeship have them teach under the supervision of some of your own inspectors.

It seems that the high school-college problem in mathematics will be partly solved when secondary schools put into effect more of the recommendations of the National Committee and when college entrance boards accept their revisions. A further step will be when only the best teachers can find permanent positions in either high school or college. The final step in its solution will come when the two groups recognize their community of interests and confer with each other to the end that there will be a better mutual understanding and greater professional progress.

GEOGRAPHY TEACHING AND CONSERVATION.

By H. H. Barrows, University of Chicago, Chicago.

The history of the American people is fundamentally a history of their rapid exploitation of the varied and abundant natural resources in their possession. Whatever preëminence they today enjoy among the nations of the world has been made possible by these resources, resources far greater than those with which nature endowed any other country, and their continued prosperity and the maintenance of their remaining resources. The question of conservation therefore is one of the more important questions confronting the nation, even in these days of vital issues. Furthermore, the need of using our lands, forests, waters, and minerals to the best advantage is certain to become more imperative as the population of the country increases.

Although notable progress has been made in recent years in the conservation of certain resources, the general situation continues to be highly unsatisfactory from the standpoint of society, and in the final analysis, its betterment depends largely on the force of public opinion. Teachers of geography can accomplish much good by helping to bring about a general realization on the part of our young citizens of the fact that our natural resources, though in most cases far from exhausted, have been and are being consumed at an alarming rate, and that enormous quantities of these resources absolutely are wasted. Most of us do not realize to what an extent this is true. Every year there is a preventable loss from erosion of more than 400,000,000 tons of soil material, more than that removed in digging the Panama Canal. In spite of the fact that a timber shortage exists in the United States today and that a timber famine is imminent unless remedial measures of an unprecedented character are adopted, highly wasteful methods are employed by most lumbermen in their logging operations, thousands of needless forest fires occur yearly, and painfully slow progress is being made in the reforestation of lands which would find their highest use in growing repeated crops of timber. On the average, half as much coal is wasted or lost in mining as is produced. Oil fields are abandoned as exhausted when most of the petroleum remains underground; petroleum is driven from the oil sands by ground waters which enter because of improper drilling; great quantities of gas are allowed to escape from oil wells into

the air; inadequate storage facilities lead to heavy losses through evaporation and seepage; the loss in many refineries still is great; and improper and wasteful uses of petroleum and its products abound. Indeed, an oil expert stated in 1919 that the resource is not made to yield more than 10 per cent of its latent value. And this is the situation in spite of the fact that petroleum is a basic necessity in our modern life, and that the reserve of natural petroleum in known fields in the United States, available by methods of production now in vogue, would be exhausted in some sixteen or eighteen years were the present output to continue.

Space does not permit further illustration of the wasteful use of resources, nor consideration of the remedies which should be applied. Teachers of geography are concerned largely with man's economic adjustment to his physical environment, with his use of earth resources. They should, so far as practicable, point the way to better adjustments and to more effective use of resources. The newer textbooks in geography are giving some attention to these subjects and there is an extended and readily available literature dealing with the problems of conservation. Society is largely responsible for the wasteful use of resources, which it often views with indifference. If teachers of geography throughout the country seize the unique opportunity which confronts them, they will help to make the attitude of the next generation of American men and women a very different one, as a result of which the nation will cease to exploit its resources recklessly and extravagantly, wasting of many things as much as it uses. The future welfare of the nation is the issue at stake.

THE SHENANDOAH CAVERNS.

The exhibition of caverns to the traveling public is noted by the United States Geological Survey as a growing industry in the Shenandoah Valley of Virginia. The famous Valley Pike, now a link in the New York to Atlanta highway, is traversed yearly by thousands of automobile tourists properly intent upon seeing America first, and no one has adequately seen America who has not visited one or more of the caverns in the Shenandoah Valley. Until recently the only caverns that were accessible to the public were the celebrated Luray Caverns, in Page County, and Weyers Caves, in northern Augusta County, near Grottoes. However, within twelve months, the Endless Caverns, near New Market, in Shenandoah County, have been thrown open to the public, and on May 31 another cavern near Mount Jackson, also in Shenandoah County, made its first bid for public favor.

The latest-opened caves have been named Shenandoah Caverns. They are about three miles south of Mount Jackson and two miles west of the Valley Pike, with which they are connected by a macadamized road. They are close to Shenandoah Caverns station, on the Harrisonburg branch of the Southern Railway, and are readily accessible both to the automobilist and to the railway tourist. Commodious rest rooms are provided near the railway. The visitor descends into these caverns by a concrete stairway and soon sees the first stalactites which appear as stout daggers of crystallized lime carbonate, hanging like icicles from points where surface water drips from the limestone roof. At the foot of the stairs is the spacious anteroom to a long chain of high-vaulted chambers connected by narrow passageways, forming in general plan a gigantic letter S, all illuminated by cleverly concealed lights. Attractive natural decorations are found in every room. Here the side walls are covered by fluted veneer done in crystal stucco, there in graceful drapery hang

creamy lambrequins in ruddy-tinted strips. From place to place, singly or in groups, are pendant stalactites and uprising stalagmites—the first inverted narrow cones fed by trickling films of lime-bearing water; the second pillars or columns fed by spattering drops of the water. Giving free rein to fancy the visitor finds resemblance in these cavern deposits to whatever he may choose from the realms of the earth or of the waters under the earth. The beasts and the birds are there, and some of the fishes; silhouette portraits of celebrities, towers and minarets, dungeons and domes, hanging gardens, high cliffs mantled by patterned growths simulating the dainty coralline fungus of moist summer groves. In one room midway down the chain the show piece is a narrow 30-foot cascade of white glittering crystal flanked by twin falls of pale translucent ocher. At the base and to the rear of this diamond cascade, visible by peering between slender columns of oriental alabaster, is the "Fairy's Secret," a tiny pool illuminated in due season by animated torches, presumably carried by a brood of phosphorescent larvae of some insect, perhaps a small fly that is commonly present in such caverns.

As he progresses from room to room the visitor is apt to think each succeeding chamber superior to the last, but whether or not this is true all are likely to agree that the most charming of all is the one that completes the inbound trip. At the end of the developed portion of the cavern a chamber of high vaulted roof suddenly gives place to a low-ceiled room containing a lakelet in which are mirrored a multitude of delicate stalactites—a pool of a thousand crystal pendants, the very quintessence of the subterranean charms.

According to A. C. Spencer, of the United States Geological Survey, the caverns of the Shenandoah Valley are far more numerous than the casual visitor would be likely to imagine. The rocks in which this broad trench-like valley has been excavated by water are mainly limestone, and wherever these rocks occur the existence of caverns is indicated by two unfailing signs—the presence of innumerable water sinks and the absence of brooks tributary to the rather regularly spaced creeks. The brookless tracts receive a due share of rainfall and must obviously contribute water to maintain the flow of the creeks and rivers, but their contributions are not delivered by way of the surface drains but through underground channels that supply copious springs in the deep valleys. The sinks are rude funnels, by means of which surface waters are diverted to the subterranean waterways.

The development of extensive underground waterways in limestone formations like those of the Shenandoah Valley hinges upon the two geologic facts that large masses of rock are always cut by joints and that limestone is dissolved by rainwater, which always contains more or less carbon dioxide. Surface water entering fissures, joint cracks, and bedding planes attacks the limestone walls and thus by a process of etching converts close fractures and joints into relatively open crevices. As this process of solution goes on lateral connections will be made from crevice to crevice, and the downward etching of the linked openings will be halted only when the subsurface water channels have become closely adjusted to the water table controlled by surface streams. Thus it is that the caverns of the Shenandoah Valley are formed.

Mr. N. D. Parker, formerly President of the Standard Scientific Company, has recently joined the Cambridge Botanical Supply Company as a general sales manager. Without question the sales of this company will be greatly increased under his splendid management. This firm publishes the Cambasco News, which is sent free to any teacher who asks for it.

MATHEMATICS IN THE UNIVERSITY OF CHICAGO.

The following university and collegiate courses in mathematics and mathematical astronomy are announced at the University of Chicago (academic year 1922-1923). All courses meet four times a week for a quarter of twelve weeks. Courses which continue for more than one quarter are indicated with Roman numerals, as I, II, III, orIV. By Professor E. H. Moore: Vectors, Matrices, and Quaternions; Matrices in General Analysis I, II, III, IV; Analytic Geometry. By Professor L. E. Dickson: Theory of Numbers I, II; Solid Analytics; Theory of Equations. By Professor H. E. Slaught: Differential Equations; Elliptic Integrals; Calculus I; Plane Trigonometry. By Professor G. A. Bliss: Definite Integrals; Elliptic Functions; Calculus II, III. By Professor E. J. Wilczynski: Projective Differential Geometry I, II; Functions of a Complex Variable; Calculus I, II; Trigonometry. By Professor F. R. Moulton: Analytic Differential Equations I, II, III; Advanced Ballistics I, II, III; Descriptive Astronomy, Sidereal Universe. By Professor W. B. MacMillan: Analytic Mechanics I, II, III; Celestial Mechanics; Descriptive Astronomy I, II. By Professor A. C. Lunn: Units and Dimensions; Dynamics of Continuous Media; Canonical Equations and Quantum Theory; Thermodynamics. By Dr. Mayme I. Logsdon: Theory of Algebraic Invariants; Calculus I, II, III; College Algebra; Analytic Geometry. By Professor J. W. A. Young: Limits and Series; College Algebra, Analytic Geometry. By Professor Kurt Laves: Plane Trigonometry; Spherical Trigonometry with Applications to Astronomy and Geodesy; Surveying; Practical Astronomy; Satellites.

THE LINCOLN SCHOOL.

Under the directorship of Dr. Otis W. Coldwell, Lincoln School, Teachers College, Columbia University, this school is making rapid strides toward accomplishing the purpose for which it was established. The appointment of Dr. Caldwell as its head meant success as this gentleman does not know the meaning of the word failure.

During the past summer there was brought together an array of some thirty speakers whose ability and reputation could not be surpassed, to discuss vital subjects of current topics in science. These lectures were given in the auditorium of the Horace Mann School. The results accomplished by this school are being studied by science educators the country over and undoubtedly the work being done here will be a pattern for science and mathematics teaching in the very near future.

FINDS FOSSIL FLOWER EMBEDDED IN ROCK.

Fossil flowers are such rare discoveries in the United States that the finding of a dogwood "flower" in a fragment of rock from the Glenrock coal field, Converse County, Wyo., is of interest. Dr. F. H. Knowlton, a paleobotanist of the United States Geological Survey, identified the fossil as a species of *Cornus*, a typical genus of the dogwood family.

There are some forty or fifty living species of the genus *Cornus*, which is widely distributed over three continents of the Northern Hemisphere and has one representative south of the Equator, a species in Peru. The leaves of more than twenty fossil species of *Cornus* have been found in North America, but the dogwood flower just identified, is the first one yet found in the United States. Species of dogwoods first appeared in the middle of the Cretaceous, the geologic period in which dinosaurs lived; in other words, the genus *Cornus* seems to have made its first appearance, probably more than four million years ago.

GRINDSTONES AND PULPSTONES PRODUCED IN 1921.

The output of grindstones and pulpstones in the United States in 1921 amounted to 26,340 tons, valued at $1,227,322, according to figures reported by the producers to the United States Geological Survey, Department of the Interior. This was a decrease from the output in 1920 of over fifty per cent in quantity and of twenty-eight per cent in value.

The grindstones produced amounted to 16,310 short tons, valued at $477,259, a decrease of 63 per cent in quantity and 61 per cent in value.

The pulpstones produced amounted to 10,030 short tons (2,940 pieces) valued at $750,063, an increase of sixteen per cent in quantity and sixty-three per cent in value. The demand at paper mills, which were very active late in 1920 and early in 1921 and which during and after the war could not renew their supply of English stone, increased the market for domestic pulpstones. If the depression that has followed this activity continues there will probably be a considerable decrease in the output of pulpstones in 1922.

The imports of grindstones and pulpstones were valued at $81,880 as against $77,046 in 1920. The exports of grindstones were valued at $281,976 as against $424,322 in 1920.

PRODUCTION OF PHOSPHATE ROCK IN 1921.

According to conservative estimates made by the United States Geological Survey from the incomplete returns available April 1, the quantity of phosphate rock sold in the United States in 1921 was about 1,968,000 long tons, valued at $10,928,300, as compared with 4,103,982 long tons, valued at $25,079,572 in 1920.

The total production of Florida was approximately 1,675,000 long tons, valued at $9,036,000.

Tennessee followed with an approximate total of 293,000 long tons, valued at $1,892,300, which included a small quantity of brown rock from Kentucky.

The western states were represented by only one producer, and South Carolina dropped out entirely.

The general business depression of 1921 is illustrated in the decline of the production of phosphate rock. The decrease in the selling price of agricultural products, combined with the high freight rates, prevented farmers from purchasing fertilizer, and the low rates of exchange discouraged exporters in the industry.

PRODUCTION OF CALCAREOUS MARL IN 1921.

The output of calcareous marl in the United States in 1921 amounted to 53,730 short tons, valued at $183,743, according to reports made by the producers to the United States Geological Survey, Department of the Interior. The quantity decreased forty-five per cent and the value forty-three per cent as compared with 1920. In 1921 the average value per ton was $3.42; in 1920 it was $3.31. Nearly all the calcareous marl sold in the United States in 1921 was used for liming the soil. Some was used as a filler in patent fertilizers. More than sixty-three per cent of the total output—33,978 short tons—was produced in Virginia and was valued at $105,821. The other producing states were California, Maryland, New York, North Carolina, Ohio, Pennsylvania, South Carolina, and West Virginia. Deposits were developed in Michigan and Wisconsin.

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg,

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

LATE SOLUTIONS.

740. Six original proofs by *Edw. A. Ravenscroft, New Trier H. S., Kenilworth, Ill.*

SOLUTION OF PROBLEMS.

741. *Proposed by Harris F. MacNeish, College of the City of New York.*

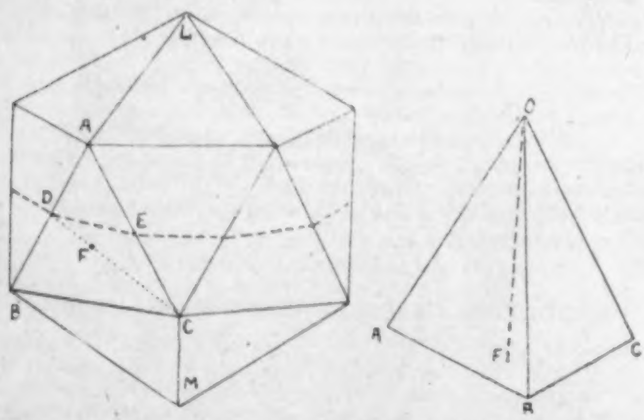
Find without using trigonometry the volume of a regular icosahedron in terms of the edge e.

Solution by Irma Luelleman and George Maischaider, Mattoon, Ill.

Pass a plane through the icosahedron perpendicular to the axis LM at its midpoint. The section formed will be a regular decagon whose side is $e/2$. The center, O, of the decagon will also be the center of the polyhedron. DE is a side of the decagon, DO its radius; OF will be perpendicular to the face ABC. After finding OF we obtain the volume of a triangular pyramid which has ABC for a base and OF for altitude.

Insert cut figures No. 5416 ∴

$BC = e$; $DE = e/2$. OD is the radius of a decagon of which DE is a side; $OD = e(1+\sqrt{5})/4$. $DC = e\sqrt{3}/2$; $DF = e\sqrt{3}/6$. $OF^2 = OD^2 - FD^2 = e^2(14+6\sqrt{5})/48$; $OF = e(3+\sqrt{5})/4\sqrt{3}$. Area of $\triangle ABC = e^2\sqrt{3}/4$. Hence the volume of the icosahedron is $20 \times \frac{1}{3} \times OFe^2\sqrt{3}/4 = 5e^3(3+\sqrt{5})/12 = 2.18e^3$ approx.



Similarly solved by *Michael Goldberg, Philadelphia, Pa.; J. F. Howard, San Antonio, Tex.; H. Lazott, Worcester, Mass.;* the *class in Solid Geometry, Culver Military Academy, Culver, Ind.;* and the following pupils of the *Dickinson H. S., Jersey City, N. J.: Ernest Lundt, Erwin Rainer, Henry Siemers,* and *Richard Slaner. E. Tabor, Upper Lake, Calif., gave* two solutions, one based on the theorems: the ratio of the surface of one side of the largest cube inscriptable in a dodecahedron of edge e is to the volume of an icosahedron of the same edge as $6{:}5e$; and the edge of such

a cube is to the edge of the dodecahedron as a line is to its major section when divided into the golden section.

II. *Solution by Norman Anning, Ann Arbor, Mich.*

To each edge of the icosahedron there is a parallel edge and these edges are opposite sides of a rectangle. An examination of the solid shows that d, the length of this rectangle, is the diagonal of a regular pentagon whose side is e. It can be shown "without trigonometry" that

$$d^2 = e^2 + ed;\ d = e(1+\sqrt{5})/2. \quad (1)$$

If we choose the center of the solid as origin a rectangular frame of reference can be so placed that all the corners lie in the coördinate planes. Thus if we have points

$$P:(0,e/2,d/2),\ Q:(d/2,0,e/2),\ R:(e/2,d/2,0)$$

joined as in the figure and if there is symmetric repetition in the other octants the resulting solid will be an icosahedron of edge e. For the edges, of which PQ is typical, are such that

$$4\overline{PQ}^2 = d^2 + e^2 + (d-e)^2 = 4e^2;\ \overline{PQ} = e = 2\overline{PM}.$$

The volume of the icosahedron is 20 times that of the pyramid, O−PQR. The area of $\triangle PQR$ is $e^2\sqrt{3}/4$. If S is the center of $\triangle PQR$ its coördinates are $x = y = z = (d+e)\sqrt{3}/6$. The altitude of the pyramid, $\overline{OS} = x\sqrt{3} = (d+e)\sqrt{3}/63$.

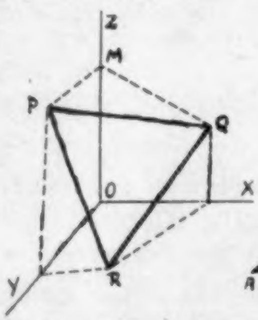
Required Volume $= (20/3)\text{base} \times \text{height} = 5ed^2/6 = 5e^3(3+\sqrt{5})/12$.

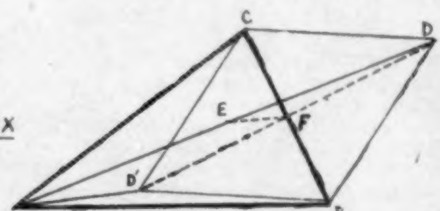
742. *Proposed by Walter E. Warne, Pennsylvania State College, State College, Pennsylvania.*

Equilateral triangles BCD and BCD′ are drawn on the side BC of a triangle ABC. Prove $(AD)^2 + (AD')^2 = a^2 + b^2 + c^2$.

Solution by H. Lazott, Worcester, Mass.

Since BCD and BCD′ are equilateral, BDCD′ is a rhombus and its diagonals bisect each other, at F. Let E be the midpoint of AD. Draw EF. Then $EF = AD'/2$.





But F is also the midpoint of CB; and CB and AD are the diagonals of the quadrilateral ABDC, and the sum of the squares of the sides of any quadrilateral equals the sum of the squares of its diagonals plus four times the square of the line joining the midpoints of the diagonals.

$$\therefore AC^2 + CD^2 + DB^2 + BA^2 = AD^2 + CB^2 + 4EF^2, \text{ or}$$

$$b^2 + a^2 + a^2 + c^2 = AD^2 + a^2 + 4(AD'/2)^2$$

which reduces to the desired equation.

Trigonometric solutions by *Thomas E. N. Eaton, Redlands, Calif.; Michael Goldberg.* By *Norman Anning, August Grossman, Blewett Junior H. S., St. Louis, Mo.,* using coordinate geometry. By F. A. *Cadwell, St. Paul, Minn., J. F. Howard, Smith D. Turner, Andover, Mass.,* using the theorem: In any triangle, the square of one side plus four times the square of the corresponding median equals twice the sum of the squares of the other sides. Also by *Harold R. Schenfler, Culver Military Academy.*

743. ***Proposed by Daniel Kreth, Wellman, Iowa.***

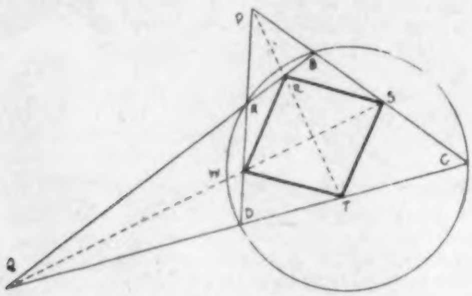
Show that $1 + x^4$ is never less than $x^2 + 2x^3$.

Michael Goldberg, and *L. R. Kellam, Culver Military Academy* mentioned

that for $x=1$ and $x=2$ the statement is not true. *J. F. Howard, E. Tabor, Smith D. Turner* showed, by solving the equation $1+x^4=x^2+2x^3$, that it is not true for valves of x between .72 and 2.34. *H. Lazott* proved that $(1+x)^4$ is never less than x^2+2x^3. The corrected statement by the Proposer is given below as problem 758.

744. *Proposed by Elmer Schuyler, Bay Ridge High School, Brooklyn.*

ABCD is a concyclic quadrilateral, where A, B, C, D are taken in order. AB and DC intersect in Q; DA and CB in P. The bisector of $\angle P$ meets AB in R and CD in T. The bisector of $\angle Q$ meets BC in S and DA in W. Prove that the figure formed by joining R, S, T, W in succession is a rhombus.



Solution by Michael Goldberg, Philadelphia, Pa.

Since the quadrilateral is concyclic, $\angle C=180°-\angle A, \angle D=180°-\angle B$. $\angle P=180°-\angle C-\angle D=\angle A+\angle B-180°$. $\angle Q=180°-\angle B-\angle C=\angle A-\angle B$.

Then $\angle Y=\angle C+\frac{1}{2}\angle P+\frac{1}{2}\angle Q=90°$ when the above values of $\angle P$ and $\angle Q$ are used.

Hence $\triangle QRY = QTY$ and $RY=TY$

$\triangle PWY=\triangle PSY$ and $WY=SY$

Then $\triangle RWY=\triangle RSY=\triangle STY=\triangle WTY$, and $WR=RS=ST=TW$ so that RSTW is a rhombus.

Also solved by *N. Anning; F. A. Cadwell; J. F. Howard; L. R. Kellam; H. Lazott; Geo. Maischaider; E. Tabor;* and *Smith D. Turner*. *L. R. Kellam* asks: what further condition imposed upon the quadrilateral ABCD will make RSTW a square? This is proposed as problem 759.

745. *For high school students. Proposed by the Editor.*

A farmer wishes to cut half of a rectangular field of grain by cutting strip of uniform width around the field. His rule for finding the width of the strip is: from the sum of the length and width subtract the diagonal and divide the result by 4. Prove the correctness of the rule.

Solution by Frederick Phelps, Jr., Newark H. S., Newark, N. Y.

Let l=length of field, w=its width, and x=width of strip. Then $lw/2=(l-2x)(w-2x)$. Multiplying where indicated and clearing of fractions: $8x^2-4(l+w)x+lw=0$. Solving by the formula:

$$x=\frac{l+w\pm\sqrt{(l^2+w^2)}}{4}$$

But $l^2+w^2=d^2$, so that $x=(l+w\pm d)/4$.

To check the result, let $l=4$, $w=3$ so that $d=5$. Then $x=12/4$ or $2/4$. But x cannot equal $12/4$ (or 3) for $w=3$ and $w-2x$ would be negative. $\therefore x=(l+w-d)/4$.

The next best solutions were by *F. Halsted Sillick, Boonton, N. J.*, and *Harlan Beem, Mattoon, Ill.* Also solved by *Esther Holland, Boonton, N. J.;* by *Geo. Maischaider, Nellie Shull, Mattoon, Ill.;* by *Homer Joy, Edward Lewis, Eva Tilton, Redlands, Calif.;* by *Asta Grona, San Antonio, Tex.*

PROBLEMS FOR SOLUTION.

756. *Proposed by Nelson L. Roray, Metuchen, N. J.*

The side AB of the parallelogram ABCD is produced to P. The line DP intersects AC at E and BC at F. A circle is drawn through B, F, P,

and from E a tangent EK to this circle. Prove that the perpendicular bisector of DK passes through E.

757. *Proposed by L. R. Kellam, Culver Military Academy, Culver, Ind.*

ABCD is a concyclic quadrilateral, where ABCD are taken in order. BA and CD intersect in Q; DA and CB in P. The bisector of $\angle P$ meets AB in R and CD in T; the bisector of $\angle Q$ meets BC in S and DA in W. Problem 744 proves that RSTW is a rhombus. What further condition imposed on ABCD will make RSTW a square?

758. *Proposed by Daniel Kreth, Wellman, Iowa.*

Show that $1+2x^4$ is never less than x^2+2x^3.

759. Anonymous.

A tells the truth 3 times out of 4; B tells the truth 2 times out of 3; C tells the truth 4 times out of 5. C makes an assertion and A and B deny it. What is the probability of the assertion being true?

760. *For high school students.*

Solve for x and y the pair of equations:

$$y^2-4y+x=0;\ x^2-x-2y=0$$

No solutions have been received of problem 755 (proposed in June for high school students) perhaps because it was published too near the end of the school year. Hence it is printed here again; solutions should reach the editor before October 20.

Problem 755. A goldsmith charged 2 per cent commission when purchasing some gold from A (meaning that A received only 98 per cent of the value of the gold), and 2 per cent when he sold the same gold to B (meaning that B paid 102 per cent of the value of the gold). But the goldsmith made an extra $25 in the deal by cheating, as he bought with a "pound" weight which actually weighed 17 oz., and sold with a "pound" weight which only weighed 15 oz. How much did A get for his gold?

PERSONALS.

At the last commencement Rutgers College conferred the degree of doctor of science on Thomas A. Edison.

James McMahon, emeritus professor of mathematics at Cornell University, died at his home in Ithaca on June 1.

The dean of the Engineering School at Rutgers College will be Professor E. H. Rockell, who comes, after long service, from Tufts College.

Dr. Howard M. Raymond has recently been appointed president of the Armour Institute of Technology at Chicago. He takes the place of Dr. Frank W. Gunsaulus, who died last year. Dr. Raymond has been dean of engineering in this institution for many years.

Dr. Herbert W. Mumford, of the University of Illinois, has been appointed dean of the College of Agriculture in this institution, as successor to Dr. Eugene Davenport, who has retired after a long period of service.

Dr. Ruth Marshall, professor of Zoology in Rockford College, spent the summer in Alaska collecting for her special work in zoology this season.

Professor Henry M. Howe, professor emeritus of metallurgy in Columbia University, died at his home in Bedford Hills, N. Y., on May 14, aged seventy-five years.

The following named persons constituted the faculty at the Camp Roosevelt Summer High, near La Porte, Indiana, during the past season: Charles H. Smith, Editor of this Journal, Principal; Frank C. Jacoby, Englewood High School, Chicago, English; E. H. Johnston, Springfield, Ill., High School, Latin; Edgar Johnson, La Porte, Ind., English and History; Miss Ella W. Kracke, Senn High School, Chicago, Botany and Zoology; George M. Lynne, Bowen High School, Chicago, Auto Mechan-

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MANUSCRIPTS. Contributions on Science and Mathematics Teaching are invited. Articles must be written on one side of the sheet only. All illustrations must be drawn or written in jet black on a separate sheet of manuscript. Contributors are requested to write scientific and proper names with particular care. Manuscripts should be sent to the Editor of **School Science and Mathematics, 5517 Cornell Ave., Chicago,** or to the proper departmental Editor. Books and pamphlets for review should be sent to the Editor. To insure insertion in any number, manuscript must be in the editor's *possession not later than the 20th of the second month before* publication.

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12 pages	6.00	1.20			

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ics; Miss Emma L. McAfee, Central High School, Tulsa, Okla., French and Spanish; M. G. Randolph, Superintendent of Schools, Perham, Minn., Science and Algebra; Arthur O. Rofe, Principal, Ray School, Chicago, English; J. M. Slogh, Oak Park, Ill., High School, Civics and History; Wendell Sooy, Banks Business College, Philadelphia, Pa., Seventh Grade Arithmetic, English and History; W. H. Spurgin, Hyde Park High School, Chicago, Chemistry and Physics; George C. Staley, Advanced Algebra, Solid Geometry and Trigonometry; S. R. Walper, Wyandotte, Mich., High School, Eighth Grade Arithmetic and Geometry; Paul E. Winklers, Wood Work, Mechanical Drawing, Surveying and Algebra.

Dr. John S. Shearer of the Physics department at Cornell University died May 18 at the age of sixty-six years.

Dr. David P. Barrows, President of the University of California, has resigned his position as President.

Professor W. L. Eikenberry, for many years departmental editor of this JOURNAL in Botany, has resigned his position as professor in the School of Education in the University of Kansas, to take the position as head of the department of science in the Pennsylvania Normal School at Stroudsburg, Pa.

The former president of Acadia University, Nova Scotia, has been elected to the Presidency of Colgate University at Hamilton, N. Y.

Mr. T. O. Walton, formerly of the Michigan Agricultural College, has been made professor of Mathematics at Kalamazoo College.

On May 20, 1922, there was unveiled in connection with the Hall of Fame of the New York University a bust of a famous woman astronomer, Maria Mitchell.

Mr. Willis E. Tower, for more than twenty years departmental editor in physics of SCHOOL SCIENCE AND MATHEMATICS, and Assistant Principal of the Englewood High School, Chicago, has been made Principal of the Libby School, Chicago.

Mr. Ira N. Van Hise, for several years instructor in Geography and General Science in the Hyde Park High School, Chicago, has accepted a professorship in Geography in the Chicago College. Mr. Van Hise has been a frequent contributor to this JOURNAL.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The White Motor Co., Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

The EDITOR will receive examination papers with many thanks. School examinations of all sorts are desired. Please send them in. Likewise any newspaper clippings similar to the question proposed in this issue.

ACKNOWLEDGMENTS.

The receipt of papers is gratefully acknowledged from:

McGill University, and Boston University; also from the Education Departments of Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, Quebec and Saskatchewan.

QUESTIONS AND PROBLEMS FOR SOLUTION.

Horse is Driven 160 Miles to Move East Side House Half Mile.

A single Dobbin and a home-made capstan still wield a power in the world, as proven yesterday when such a combination completed the moving of a two-story house from 8043 Superior Avenue S. E., to Derby

The dwelling, too wide for some of the streets on the route, was moved in halves. Each half weighed twenty-five tons, it was estimated by F. H. Ames, moving contractor in charge of the work.

In supplying the power the horse walked 160 miles, while the house traveled its one-half mile. Traffic on Superior avenue N. E. was suspended in the early hours of two mornings and trolley wires were removed between E. 82d and E. 86th Street while the moving was in progress.

395. *Suggested by the newspaper clipping above.* (*Cleveland Plain Dealer*).

1. What kind of a rig did Mr. Ames use for this work?
2. What force did the horse exert?
3. How much work did he do?
4. Could this house have been moved on skids? Why?

Those specially alert for projects of a really practical turn might set their classes at this thoroughly practical problem which has been solved by a practical man in a practical way.

Send in some solutions, please.

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PHYSICS.

Friday, June 17th, 1921. Afternoon—2.00 to 4.00.

Candidates will do Part A or Part B.

PART A.—MERCHANT AND CHANT.

(Only *seven* questions to be attempted.)

1. Explain the terms, velocity and acceleration. Give an illustration of each. A stone is dropped into a well and in three seconds reaches the bottom. Find (*a*) the velocity it had on reaching the bottom, (*b*) the depth of the well.

2. Define: work, power, energy and two units of each. A locomotive pulling a train along a level track at the rate of 25 miles an hour expends 75 horse-power. Find the resistance overcome.

3. What is meant by hydrostatic pressure? What are the laws of hydrostatic pressure? Describe one experimental application of hydrostatic pressure demonstrated in your class-room or laboratory.

4. State Boyle's law. Gas is forced into a tank having a volume of 2 cu. ft. until the pressure of the gas is 250 pounds per sq. in. The gas is allowed to expand into a larger tank exhausted of air and on measuring the pressure it was found to be 50 pounds per sq. in. What is the volume of the larger tank?

5. Distinguish between temperature and heat. Define the units of heat. Describe the construction and graduation of an instrument for measuring temperatures.

6. Define the specific heat of a substance. How can the specific heat of a substance be determined experimentally? 150 grams of mercury at 80°C. is mixed with 120 grams of water at 0°C. The resulting temperature is 3.2°C. Find the specific heat of the mercury.

7. Account for the formation of dew, snow, and clouds. Explain the term relative humidity. Why does the temperature seldom fall below the dew-point during a shower of rain?

8. Describe any two of the following and indicate the underlying principle in each case: (*a*) A double action force pump, (*b*) an air pump, (*c*) the Westinghouse air-brake, (*d*) an intermittent siphon.

PART B.—LYNDE.

(Answer *seven* questions only.)

Back numbers wanted. January, February and May, 1920. 20 cents each, or 25 cents allowed on subscription.

1. Name mechanical appliances in daily use based on each of the following: (*a*) Six on the lever, (*b*) six on the wheel and axle, (*c*) six on the screw. Indicate by diagram the forces acting in any three of the appliances.

2. Define: force, work, and two units of work. Explain the effect of friction on the work done by a machine.

3. Describe one practical mechanical application of hydrostatic pressure made use of in either city or country homes. What is the principle underlying Artesian wells?

4. State (*a*) Pascal's law, (*b*) the law of Archimedes. How may Archimedes' law be proved experimentally? One cubic foot of wood floats with one-fourth of its volume out of water; what is the weight of the cube?

5. Describe one form of gas meter. Who receives the larger quantity of gas per 1000 cu. feet, the occupant of an upper apartment or the occupant of a lower apartment? Explain.

Name other applications depending on the properties of gases, made use of by man.

6. Explain any three of the following: (*a*) the principle involved in liquid-in-glass thermometers, (*b*) the principle underlying some form of recording thermometer, (*c*) the principles involved in ventilation, (*d*) the principles by which hot water may be obtained from a hot-water tank system.

7. Define: (*a*) The latent heat of fusion, (*b*) the latent heat of vaporization, (*c*) the specific heat of a substance. Explain what becomes of the heat absorbed in changing a solid to a liquid. How much steam at 100°C. must be passed into 500 grams of water at 10° to raise the mixture to 40°C.?

8. Comment on the following so as to indicate clearly what physical conditions and changes are involved: (*a*) evaporation, (*b*) saturation, (*c*) formation of dew and fog, (*d*) the boiling of a liquid, (*e*) cooling by evaporation.

SUPERIOR SCHOOL EXAMINATIONS.

Province of Quebec.

SUPERIOR SCHOOL EXAMINATIONS, FRIDAY AFTERNOON, JUNE 17, 1921, FROM 2 TO 5.

PHYSICS, GRADE X.

(*Answer any nine questions.*)

1. Make a drawing of an ordinary air-pump, and show how it works.
2. What is a siphon? Explain carefully the principle on which it works.
3. A flask weighs 280.6 gm. when empty, 284.2 gm. when filled with air, and 3060.6 gm. when filled with water. Find the weight of one litre of air.
4. Describe carefully the construction of the cistern barometer and explain the principle on which it works and the uses to which it is put.
5. State the principle of Archimedes. Explain how one can determine the density of an irregular piece of marble. How can the density of a liquid be found?
6. What is Pascal's Principle? What is the Hydraulic Press? Explain how it works.
7. Into what classes are levers divided? Give an example of each class.
8. (*a*) The speed of sound, at 61° F., is 341 metres per second; express this in feet per second. (*b*) A tank 50 cm. long, 20 cm. wide, and 15 cm. deep is filled with alcohol of density 0.8. Find the weight of the alcohol.
9. Find the space passed over when a body falls for five seconds. (In vacuum.) State Newton's Three Laws of Motion.
10. What is meant by the Centre of Gravity of a body? Under what conditions is a body in equilibrium? What are the different states of equilibrium?

BOOKS RECEIVED.

Vegetable Growing Projects, by Ralph L. Watts, Pennsylvania State College. Pages 23 + 318. 13.5x21 cms. Cloth. 1922. The Macmillan Company, New York City.

The World of Sound, by Sir William Bargg, University of London, England. Pages VIII + 196. 13x19 cms. Cloth. 1922. $2.00. E. P. Dutton Company, 681 5th Avenue, New York City.

Beginners Algebra, by Clarence E. Comstock, Bradley Polytechnic Institute, and Mabel Sykes, Bowen High School, Chicago. Pages VIII + 303. 14x20 cms. Cloth. 1922. Rand, McNally & Co., Chicago.

Plane Geometry, by Mabel Sykes, Bowen High School, and Clarence E. Comstock, Bradley Polytechnic Institute. Pages XII + 322. 14x20 cms. Cloth. Rand, McNally & Co., Chicago.

Solid Geometry, by Mabel Sykes, Bowen High School, and Clarence E. Comstock, Bradley Polytechnic Institute. Pages VIII + 218. 14x20 cms. Cloth. 1922. Rand, McNally & Co., Chicago.

First Book in English for High Schools, by A. L. Murray, Normal School, Eau Claire, Wisconsin, and E. P. Wiles, X + 478. 13x19 cms. Cloth. 1922. D. C. Heath & Co., Chicago.

Chemistry and Its Uses by William McPherson and William E. Henderson. Pages VIII + 447. 14x19 cms. Cloth. 1922. Ginn & Company, Boston, Mass.

Transactions of the Illinois State Academy of Science 14th Annual Meeting compiled by the Secretary, C. F. Phipps, State Teachers' College, DeKalb. 326 pages. 15.5x23 cm. Paper. 1922. Published by the State, Springfield.

Graphs, Plane Geometry Practice Pad, Solid Geometry Practice Pad, Loose Leaf outlines in Observational Geometry and Numerical Trigonometry, and Loose Leaf Outlines in Algebra, by Charles H. Sampson, Huntington School, Boston, 1922. McIntosh Publishing Company, Dover, N. H.

Applied Calculus, by F. F. P. Bisacre, Glasgow, Eng. Pages XV + 446. 14x20 cm. Cloth. 1922. $3.75 net. D. Van Nostrand Company, New York.

Analytic Geometry, brief course by Lewis P. Siceloff, George Wentworth and David E. Smith. Pages VI + 186. 14.5x20.5 cm. Cloth. 1922. $1.80. Ginn & Co., Boston.

Cornell Alumni Directory. Pages XXII + 582. 15x32 cm. Paper. 1922. Published by the University at Ithaca, N. Y.

List of Books for School Libraries in the State of Wisconsin, John Callahan, State Superintendent. 94 pages. 15x23 cm. Paper. 1922. Madison, Wisconsin.

Solid Geometry, by Herbert E. Hawkes, Columbia University, William A. Luby, Junior College, Kansas City, and Frank C. Touton, University of California. Pages XV + 192. 13.5x19 cm. Cloth. 1922. Ginn & Co., Boston, Mass.

Machine-Shop Mathematics, by George Wentworth, David E. Smith, and Herbert D. Harper. Pages III + 162. 13.5x19 cm. Cloth. 1922. $1.20. Ginn & Co., Boston, Mass.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for May, *Brooklyn Botanic Garden, Brooklyn, New York*. $6.00 *per year*, 75 *cents a copy*. "Potato ovules with Two Embryo Sacs," W. J. Young; "Vegetative Vigor of the Host as a Factor Influencing Susceptibility and Resistance to Certain Rust Diseases of the Higher Plants II," M. A. Raines; "Lignification of Mature Phloem in Herbaceous Types," Carl L. Wilson; "Observations on the Effect of Water-raking on the Keeping Quality of Cranberries," H. F. Bergman; "Incipient Drying and Wilting as Indicated by Movements of Cocoanut

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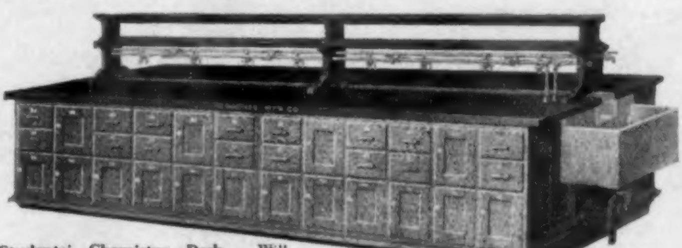

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Built for Science

Pinnae," Sam F. Trelease; "Dr. W. J. Beal's Seed-viability Experiment," H. T. Darlington; "Nutrient Solutions for Wheat," W. E. Tottingham and E. J. Rankin.

American Mathematical Monthly, for January, (issue late) *Lancaster, Pa.*, $4.00 *per year*, 45 *cents a copy*. "Cuspidal Envelope Rosettes," W. F. Rigge; "Sexagesimal Fractions among the Babylonians," F. Cajori; "A Budget of Exercises on Determinants," Sir Thomas Muir; "Among My Autographs: 18. Sylvester as a Poet; 19. Lewis Carroll as a Critic," D. E. Smith; "Undergraduate Mathematics Clubs: Club Activities—Adelphi College; Cooper Union; Denison University; Goucher College; University of North Carolina; Smith College; Trinity College; State College of Washington; Problems and Solutions: Problems for Solution—2941-2950. Notes—25. "The area of a quadrilateral," Professor Archibald.

Condor, for May-June, *Pasadena, California*, $2.00 *per year*, 40 *cents a copy*. "Miscellaneous Bird Notes from Montana" (with two illustrations), Charles L. Whittle; "Wasted Ornithological Material" (with one photo), W. H. Bergtold; "Notes on the American Pine Grosbeaks, with the Description of a New Sub-species," Allan Brooks; "The Aleutian Rosy Finch" (with one photo), G. Dallas Hanna; "Eggs of the Aleutian Rosy Finch" (with one photo), Joseph Mailliard.

Education, for June, *Boston, Mass.*, $4.00 *per year*, 40 *cents a copy*. "Biology: Its Educational Value Socially Considered," John C. Page; "Moral Education in the Public Schools," Susan W. Norton; "The High School Physics Course," A. W. Forbes.

Nature-Study Review, for April, *Ithaca, N. Y.*, $1.56 *per year*, 20 *cents a copy*. "The Summer Camp and Nature-Study," W. G. Vinal; "Camp Nature Ideas in the Classroom," M. M. Cornell; "Eight or Nine Words about Nature-Study," E. J. Dole; "Gypsies," Charlotte V. Gulick; "Canoeing and Nature-Study," Dr. J. B. May; "Nature Study at Quanset," Mrs. E. A. W. Hammatt; "A Modern Fairy Story," H. E. Childs; "Nature-Study in Camp," Fannie A. Stebbins; "A Boys' Camp That Almost Became Famous."

Photo-Era, for June, *Boston, Mass.*, $2.50 *per year*, 25 *cents a copy*. "Hot-Weather Photography," W. X. Kincheloe; "The Professor on Constructive Photography," W. T. Adderley; "Letting George Mis-Do It," B. Patang; "The Camera in Girls' Camp," Dr. Edward F. Bigelow.

Popular Astronomy, for June-July, *Northfield, Minn.*, $4.00 *per year*, 50 *cents a copy*. "The Present Position of the Island Universe Theory of Spiral Nebulae," with Plate XXV, Dean B. McLaughlin, concluded; "Aberration and Relativity," William H. Pickering; "Differential Refraction in Positional Astronomy—A Review," Ralph E. Wilson; "A Universal Scale for the Solution of Astronomical Problems," J. Ernest G. Yalden.

Toneya, for May-June, *Lancaster, Pa.*, $1.00 *per year*, 30 *cents a copy*. "Some Amateur Observations on Color-forms," C. A. Weatherby; "Some Interesting Plants from Long Island," W. C. Ferguson.

BOOK REVIEWS.

List of Books for School Libraries in the State of Wisconsin, prepared by O. F. Rice and Irene Newman. 94 pages. Paper. 1914.

The Madison, Wisconsin, list of books given in this pamphlet constitute the books which may be placed in the high school libraries of the state. It is a remarkable list. It shows much study and thought in the selection. The books on science, especially, are all up-to-date. They are standard in every respect. According to the law of 1921 the sum available for the purchase of books is twenty cents per person of school age. The book shows all necessary directions for the ordering and selecting of books. It is presumed that it is possible for anyone to secure a copy of this list by applying to the state superintendent at Madison.

C. H. S.

The World of Sound by Sir William Bargg, University of London, England. Pages viii+196. 13x19 cms. Cloth. 1922. $2.00. E. P. Dutton & Co., 681 5th Ave., New York City.

We find this is an outline of six lectures delivered at a Juvenile Auditory, Royal Institution, England, by the author. It is a very interesting and comprehensive book. It is one that can be read and understood by the ordinary high school pupil. There are ninety-three drawings and pictures, most of which have been made especially for this text, and they all are so clearly represented that the individual will have no difficulty in understanding them. There are six chapters as follows: One, "What is Sound;" two, "Sound and Music;" three, "Sounds of the Town;" four, "Sounds of the Country;" five, "Sounds of the Sea;" and six, "Sounds in War." It is printed in ten-point type, and is the English way of presenting things. It is printed on calendered paper, thus reducing the light reflection to a minimum. Mechanically, the book is well made and is one that every physics teacher should possess.

C. H. S.

Applied Calculus, by F. F. P. Bisacre, O.B.E., M.A., B.Sc., A.M. Inst. C. E. Pages xiv + 446. 14x20 cm. Price, $3.75. 1921. D. Van Nostrand Company, New York.

This book is intended to provide an introductory course in calculus for the use of students of natural and applied sciences who have little knowledge of mathematics. Infinite series and difficult integrations are not treated. The last three chapters, 136 pages, are given to problems in electricity, magnetism, chemical dynamics, and thermodynamics, and should prove very helpful to persons who are meeting these problems in their daily work. However, the average student in calculus would find his knowledge of these subjects too limited to derive the greatest value from a study of these problems. As a book of reference for teachers and students of calculus and as a text-book for workers in applied science this book is highly recommended. H. E. C.

Beginners' Algebra, by Clarence E. Comstock, Professor of Mathematics, Bradley Polytechnic Institute, and Mabel Sykes, Instructor in Mathematics, Bowen High School, Chicago. Pages viii + 301. 13.5x19.5 cm. 1922. Rand, McNally and Company, Chicago.

This is the first of a two-book series and includes no more work than can be completed easily in one year. The introductory chapter reviews fractions and decimals, and throughout the book arithmetic and algebra are closely connected. The equation as a means of solving problems is given main consideration though the function idea is recognized in a substantial way in connection with graphs, which are made an essential part of the course. The order of topics is not the traditional one, but the new order seems to be justified. The explanations and illustrations are good and ought to be readily understood by the students. H. E. C.

Solid Geometry, by Mabel Sykes and Clarence E. Comstock. Pages viii +218. 1922. Rand, McNally and Company, Chicago.

The Solid Geometry has the same general features as the Plane Geometry published in 1918. In both books the two main characteristics are analysis and emphasis. By analysis of problems pupils are trained in attacking difficult problems, and the work is so arranged as to throw emphasis on the important theorems and methods. The surfaces and solids usually studied in solid geometry with the exception of the sphere are discussed in chapter ii, all areas and volumes are considered in chapter

iv, and similarity in chapter v. At the close of the book are: Notes on Arithmetic and Algebra, Tables, and References and Topics for Mathematics Clubs. H. E. C.

Intermediate and Advanced Algebra, bu Murray J. Leventhal, A.B., A.M., Instructor in Mathematics, Stuyvesqnt High School, New York City. Pages 96. 14x19 cm. Paper covers. 1921. Globe Book Company, New York.

This second edition, revised and enlarged, contains problems for the second year's work in Algebra. It is adapted for use in schools where teachers desire to keep pace with recent modifications in the intermediate and advanced algebra syllabi. It meets the precise requirements of the best secondary schools, and includes such topics as graphical representation, logarithms, progressions, permutations and combinations, theory of equations, determinants, and undetermined coefficients. H. E. C.

Plane Geometry Practice Pad, Solid Geometry Practice Pad, and Graphs, by Charles H. Sampson, Head of the Department of Mathematics, Huntington School, Boston. 13x20 cm. Graphs. 19.5x27 cm. 1922. McIntosh Publishing Company, Dover, N. H.

The geometry pads present problems and questions for the purpose of securing a systematic and complete review of the fundamental theorems and definitions of geometry. If the advanced work is completed so that a month can be allowed for the review here given the author believes that the college entrance examinations can be passed successfully.

The Graph Pad is planned for a definite period, one week or more, for an intensive study of the graph before the college entrance examinations. Explanations are given on the sheets of squared paper. It would seem as if the definitions of the comic sections should be given correctly.

H. E. C.

Loose Leaf Outlines in Observational Geometry and Numerical Trigonometry. Loose Leaf Outlines in Algebra, by Robert R. Goff, Director of Mathematics, Academic High School, New Britain, Conn. Pages 18 each. 20.5x26.5 cm. 1922. The Palmer Company, Boston.

The aim of the first outline is to help the student make the acquaintance of the basic principles of plane gemoetry, the sine, cosine, and the tangent, and the application of all these two real problems. The plan is to have models of every definition and process made by each pupil under the teacher's guidance, and inserted in the proper space. The outline is a complete text-book and follows closely the recommendations of the National Committee on Mathematical Requirements.

The aims of the outlines in algebra are to organize the material, separate essentials from non-essentials, emphasize fundamentals and methods, and summarize related facts and processes. They can be used with any text-book. The price is 50c, complete with notebook cover. H. E. C.

Vocational Guidance Tests, by L. L. Thurstone, Carnegie Institute of Technology. World Book Company, Yonkers-on-Hudson, New York.

This series of five tests is designed to be used together to test high school seniors and college freshmen to determine their probable success in an engineering college. The items in the tests were selected as having a direct appeal to students with engineering interests. They include tests in arithmetic, algebra, geometry, physics, and the technical information test. The tests are in packages of twenty-five with key and record sheet (except that geometry test has no key), price per package, $1.00. The manual of directions, 22 pages, is 20 cents. H. E. C.

Analytic Geometry, Brief Course, by Lewis P. Siceloff, George Wentworth, and David Eugene Smith. Pages vi + 186. 14.5x21 cm. Price, $1.80. 1922. Ginn and Company, Boston.

This book aims solely to set forth the leading facts of the subject clearly, succinctly, and in the same manner that characterizes the other text-books of the series. It presents the essential features of the analytic method, the equations and simpler properties of the comic sections and a few other important curves, and the theory in the space of three dimensions, that can be covered in half a year. A special effort has been made to present the material in so natural and simple a manner that the student can comprehend it largely through his own reading. H. E. C.

Fundamentals of Practical Mathematics, by George Wentworth, David Eugene Smith, and H. D. Harper. Pages vi + 202. 13x19 cm. Price, $1.20. 1922. Ginn and Company, Boston.

The foundation work in mathematics in which all students preparing for any of the usual trades should be well grounded is presented in admirable fashion. It reflects closely shop conditions and gives many blue prints on which the problems are based. The fundamental operations, ratio and proportion, mensuration, angle functions, and the slide rule are dealt with in a very practical way, making a text-book that will prove useful in schools given over largely to vocational or prevocational training. H. E. C.

Machine Shop Mathematics, by George Wentworth, David Eugene Smith, and H. D. Harper. Pages iii + 162. 13x19 cm. Price, $1.20. 1922. Ginn and Company, Boston.

This book is intended for those students who expect to become machinists and is entirely confined to the mathematical caclulations required in the work of the machine shop, including measuring instruments, speeds and feeds, tapers and taper-turning, screw-threads, indexing and spiral cutting, and gears. The final chapters deal with general problems relating to all types of machine work and give some of the more important tables used in the machine shop. There are many drawings and photographic reproductions of machine tools. H. E. C.

List of Books for School Libraries in the State of Wisconsin, Prepared by O. F. Rice, and Irene Newman. 94 pages. Paper. 1914.

The Madison, Wisconsin, list of books given in this pamphlet constitute the books which may be placed in the high school libraries of the state. It is a remarkable list. It shows much study and thought in the selection The books on science, especially, are all up-to-date. They are standard in every respect. According to a law of 1921 the sum available for the purchase of books is twenty cents per person of school age. The book shows all necessary directions for the ordering and selecting of books. It is presumed that it is possible for anyone to secure a copy of this list by applying to the state superintendent at Madison. C. H. S.

The Naturalist of the Great Lakes Region, by Elliot R. Downing, University of Chicago. Pages XXV + 328. 452 illustrations. 14x20 cms. Leather. 1922. $3.65 post-paid. University of Chicago Press.

It has always been a pleasure to review the books coming from the pen of this well-known author, and it is a super-pleasure to be able to say something in favor of his most recent production. For those people who are interested in nature study, especially, in the Great Lakes region, there is no better book for them to consult and study, and it is a text of this kind that is creating in the minds of the public a desire to know more of woods, prairie, dune, and dale. The book is an advanced general

science; yet it is written in such a clear, concise, and interesting way that even a freshman in high school can understand it, although I suppose it is primarily intended for an older class of people, especially those who are in love and in touch with nature, and these will welcome this book as they have never welcomed any other. The several types of landscape are treated distinctly, dune, prairie, river, forest, and valley receiving their proper space. The book is divided into fourteen chapters as follows: one, The Changing Face of Nature; two, The World in the Making; three, The Story of our Rock Foundation; four, The Glacial Period; five, Lake Chicago and its Old Shore Lines; six, Distribution and Adjustment; seven, The Dunes and Their Plants; eight, Animals of the Dunes; nine, Interdunal Ponds and Tamarack Swamps; ten, The Climax Forest and Its Predecessor, the Oak-hickory Type; eleven, Lake to Forest or Prairie; twelve, Lake Bluff, Ravine, and River Valley; thirteen, Brook, Creek, and River; and fourteen, Some Sources of Our Fauna and Flora. The half-tones and drawings of which there is such a profuse display were practically all made primarily for this text, and it gives one some idea of the expense, time, and care, and forethought given to the preparation of the text by the author. The book is printed in clear ten-point type on paper that is not too glossy, thus making it very easy to read, as the glare and reflection of light are eliminated. There is a splendid outline of the important plant and animal associations given in one of the appendixes; also a bibliography of books kindred to this particular text. A complete and splendid index of eighteen double column pages is given. It is a beautiful book in every way. It is a guide to nature in the region described. It tells about living things. It is just about the right size to carry in the pocket, and the limp cover makes it easy to carry. It is a splendid book to place on the library table, as it surely will direct readers; and above all it is authoritative. It should be in the possession of every lover of nature. C. H. S.

The World of Sound, by Sir William Bargg, University of London, England. Pages VIII + 196. 13x19 cms. Cloth. 1922. $2.00. E. P. Dutton & Co., 681 5th Ave., New York City.

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Vegetable Growing Projects, by Ralph L. Watts, Pennsylvania State College. Pages 23 + 318. 13.5x21 cms. Cloth. 1922. The Macmillan Company, New York City.

One may consider this a regular hand-book for growers of vegetables. It is a most remarkable and reliable book, and the reviewer thinks it is up-to-date in all respects as far as home and market gardening are concerned. The name of the author is sufficient to give an idea of the nature of the work and the authority which it carries with it. It is a guide for studying all kinds of vegetables, growing and developing in all phases.

REVISED LIST OF MEMBERS, EDUCATIONAL PRESS ASSOCIATION OF AMERICA, 1922

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National Geographic Magazine, Washington, D. C.	Gilbert H. Grosvenor
Nebraska Teacher, Lincoln	George L. Towne
New Mexico Journal of Education, Santa Fe	
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Pennsylvania School Journal, Harrisburg	
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Primary Education, Boston, Mass.	Mrs. Whiting
Porto Rico School Review, San Juan, P. R.	Carey Hickle
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School Science and Mathematics, Chicago	Chas. H. Smith
School News, Taylorville, Ill.	L. L. Parker
School News, Newark, N. J.	John C. Evans
Sierra Educational News, San Francisco, Calif.	Arthur Chamberlain
Southern School Journal, Lexington, Ky.	R. S. Eubank
Southern School Work, Alexandria, La.	C. R. Reagan
South Dakota Educator, Mitchell	F. L. Ransom
Texas School Journal, Dallas	H. T. Musselman
Utah Educational Review, Salt Lake City	L. E. Cowles
Wisconsin Journal of Education, Madison	W. N. Parker

There is an explanation and suggestions with reference to the program of work in raising vegetables. There are seventy-nine figures, most of which have been purposely selected for this particular work. There is a splendid vegetable-growing calendar given on pages two to thirty-five inclusive. There are twelve chapters in the book as follows:

Chapter one—Vegetable Growing Project Calendar or Seasonal Program; chapter two—Solanaceous Crop Projects; chapter three—Cole Crop Projects; chapter four—Salad Crop Projects; Chapter five—Vine Crop Projects; chapter six—Root Crop Projects; chapter seven—Tuber Crop Projects; chapter eight—Bulb Crop Projects; chapter nine—Pulse Crop Projects; chapter ten—Perennial Vegetable Projects; chapter eleven—Sweet Corn Project; chapter twelve—Home Garden Projects.

There are distributed throughout the text many questions and themes for discussing how to raise plants and vegetables. The major paragraphs begin with bold-faced type, thus indicating the nature of the discussion in that paragraph. It discusses various kinds of sprays for insects. It is a book that every botany and agricultural teacher of the United States should possess, and with its four pages of double column index it is very easy to find the place where every particular step is discussed.

C. H. S.

Barber's Standardized Science test for General Science.

It takes a pretty well educated person in science to be able to teach nowadays successfully the subject of general science, because it embodies so many different sciences if the work is to be done efficiently. These little tests that Mr. Barber has prepared for general science teachers cover in a remarkable degree all phases of the work. Any general science teacher who has the interest of his work at heart should prepare himself with a set of these tests. They may be had from A. B. Barber, Clayton, New Mexico.

Modern Business Arithmetic, by H. A. Finney, Professor of Accounting, Northwestern University, and J. C. Brown, President, State Teachers' College, St. Cloud, Minn. Pages vi + 485. 14x20 cm. 1922. Henry Holt and Company, New York.

This revised edition provides a year's work in the arithmetic of modern business and includes topics which have acquired importance recently because of changes in organization and conduct of business. While abundant material for practice and drill is provided, the work in each chapter is so presented that the student sees the business need of each process and numerous practical problems based on actual business practices of today are given. In all respects this is a most excellent text-book. H. E. C.

Solid Geometry, by Herbert E. Hawkes, Ph.D., Professor of Mathematics in Columbia University, W. A. Luby, M.A., Head of the Department of Mathematics in the Junior College of Kasnas City and Frank C. Touton, D.Ph.D., Lecturer in Education, Department of Education, University of California. Pages XV + 192. 13x18 cm. Price, $1.24. 1922. Ginn and Company, Boston.

Book VI, on lines and planes, as presented in many text-books is so dry and uninteresting that it is a pleasure to see how it can be enlivened by the large number of exercises and queries introduced by the authors. The volumes of rectangular solids, cylinders, are based on assumptions and theorems without proofs, which is a most sensible procedure. Cavalieri's theorem replaces the usual theorems for other volumes which are so trying and mystifying to the average student. There are many practical applications and the hundreds of queries encourage the student and teacher to use and develop the scientific imagination. H. E. C.